

Science in the Dock

First published 1942
This edition 1944

Printed in Great Britain by Blackie & Son, Ltd., Glasgow

PREFACE

At the present time there is probably no class of men so concentrated on their work as men of science. Many of them, probably most of them, developed in their school laboratories a manual skill that tended to foster a liking for the subject in the Fourth Form, with the consequence that at much too early an age they began to neglect and eventually to belittle humanistic subjects. In their First school examination, that for School Certificate, they may have obtained Distinctions in one or two branches of science, and were thus probably encouraged to become science specialists in the Sixth Form, and later at the University to take up science exclusively. They drifted away from serious literature and history at the age of 14 or 15, an age when they could not have made more than a nodding acquaintance with humanism and the humanities in the deeper sense. When therefore later in life they might have been expected to help towards the solution of the world's urgent human problems, they were almost like little children. They could, readily enough, measure and weigh, analyse and synthesize, make scrupulously accurate records, and from rigorously sifted objective facts could reason accurately, but the great unsolved abstract and subjective problems of life had nothing more than a passing interest for them.

I fear that, during my professional career, I advocated the claims of science teaching much too strongly, and I am now quite sure that the time often devoted by young boys to laboratory practice, and to the purely mathematical side of science, more especially chemistry and physics, was far too great.

At the moment, science is devoting itself to forging new weapons of destruction. The war once over, will there not be an urgent need for men to beat their swords into ploughshares—to abandon the manufacture of murder's weapons and instead to construct implements and instruments which will contribute to the world's happiness and help to foster mutual human affection?

I have consulted the works of many distinguished authorities on science, philosophy, and kindred subjects, and from some of them I have quoted freely. A list will be found on pp. 129-30.

Sept. 1941.

ACKNOWLEDGMENTS

I have pleasure in acknowledging my indebtedness to:

Allen & Unwin Ltd.: *The Deeper Causes of the War and its Issues*.

The Cambridge University Press: *Cambridge Essays on Education*; *Cambridge Essays on Adult Education*.

Sir Richard Livingstone: *B.A. Presidential Address*.

Longmans Green & Co. Ltd.: "The Education of the World" in *Essays and Reviews*. Frederick Temple. "On the Interpretation of Scripture" in *Essays and Reviews*. Jowett.

Macmillan & Co. Ltd.: *Liberal Education*. T. H. Huxley.

A. D. Peters: *What Dare I think?* Professor Julian Huxley.

The Times Educational Supplement: Articles "In Praise and Defence of Public Schools" and "Public and Other Schools".

Williams & Norgate Ltd.: *Education, Intellectual and Moral*, Herbert Spence; *Organization of Thought*, Professor A. N. Whitehead.

CONTENTS

CHAP.		Page
I.	CONVICTIONS AND PREJUDICES.	
	1. Pre-adolescent " Convictions " - - - - -	1
	2. The Post-adolescent Convictions of the Majority - -	3
	3. Convictions and Opinions: Persuasion and Prejudice -	6
II.	SCIENCE IN THE DOCK: THE CASE FOR THE PROSECUTION -	10
III.	SCIENCE: THE VAST FIELD IT NOW COVERS.	
	1. The Science of the Nineties - - - - -	16
	2. The Mathematical Part of the Science Field - -	17
	3. A Brief Summary of the Field as a whole - - -	18
	4. Science and the Future - - - - -	28
IV.	SCIENCE: ITS METHODS.	
	1. Animals: their apparently Methodical Ways - -	33
	2. Primitive Man - - - - -	34
	3. The Methods of Scientific Workers - - - -	36
	4. The Science Worker in his Laboratory - - -	42
	5. The Researcher as a Thinker - - - - -	45
V.	SCIENCE: HOW FAR RESPONSIBLE FOR WAR.	
	1. War in History - - - - -	51
	2. The Causes of War: Opinions of Eminent Men - -	54
VI.	SCIENCE AND CIVILIZATION.	
	1. Civilization - - - - -	62
	2. Progress and Decay - - - - -	65
	3. Power: Discipline v. Liberty - - - - -	67
	4. Science: is it the Main Source of Power? - - -	71
	5. Science: The Friend or Enemy of Civilization? - -	76
	6. World Reconstruction: Utopian? - - - - -	79

CHAP.		Page
VII.	SCIENCE AND EDUCATION.	
	1. Opinions of Distinguished Educators - - - -	84
	2. The Education of Nazi Youth - - - -	91
	3. Socialism v. Individualism - - - -	93
	4. Science as a whole now too vast for any one man to master	95
	5. A British Weakness: Illogical Reasoning - - -	97
	6. The Hebrews and the Ancient Greeks as our Mentors -	98
	7. Education: Present-day Tendencies - - - -	99
	8. The Future of the Public Schools - - - -	106
VIII.	SCIENCE AND RELIGION.	
	1. Fields of Experience: Different Impressions on different Minds - - - -	108
	2. Miracles and Science - - - -	112
	3. Agnosticism - - - -	112
	4. Theism - - - -	114
	5. Jesus, the Christ - - - -	117
	6. The Creeds - - - -	118
	7. Creeds and Conscience - - - -	120
	8. The New Religious Outlook - - - -	122
	9. Immortality - - - -	123
	10. Voices from London and Washington - - -	126
IX.	THE CONDEMNATION OF SCIENCE: VERDICT - - -	128
	WORKS OF REFERENCE - - - -	129
	INDEX - - - -	131

CHAPTER I

Convictions and Prejudices

1. Pre-adolescent "Convictions".

I was a boy of about twelve or thirteen, an age at which impressions of the doings of one's elders are still accepted almost without question as readily as they were in much earlier childhood, when four incidents relating to foreigners came under my notice, and the impressions left on my mind were indelible.

1. In that romantically attractive bit of England between the Wye and the lower Severn, the Forest of Dean, the road from Ruardean to Mitcheldean runs through the village of Drybrook, and onwards over the hill known as the Stenders which forms the boundary of the Meend, a piece of open grassland of some hundreds of acres, attractive, but to strangers treacherous because of its many "quabs"—great holes in the undrained turf, perhaps twenty feet deep and fifty or sixty feet across, filled with soft and easily yielding mud, but luring the unwary by carpets of coarse green grass.* One afternoon some sixty years ago I joined other boys who were accompanying a number of men hurrying to one of these quabs where a straying horse was already half immersed and was gradually sinking. Within ten minutes, only the animal's head and neck remained above ground. The men were helpless. As the head disappeared below the surface, the final piercing scream was beyond all telling. In the crowd of lookers-on, there happened to be a travelling German "pack-man"—a tailor's tout from Birmingham who made his living by obtaining orders from the local colliers, and his

* elsewhere, quagmires.

remark on hearing the horse's scream was, "that was really a cheap bit of fun". He only just escaped being thrown into the quab by the angry and over-wrought little crowd.

2. Another incident took place, within a year or so, three or four miles from the same spot. Two Russians were making a living in England by travelling from place to place with two performing bears, and the rumour had got abroad that the bears had seized and killed a local child. A crowd of colliers just up from their coal-mine in the early afternoon, hearing the rumour, excitedly followed the trail and eventually overtook the Russians and their bears and cudgelled the latter to death. The Russians literally fell on their knees and begged for mercy, but they had scarcely any knowledge of English and they were not understood. But the bears being dead, the excitement of the crowd died away, and when a passing horseman assured them that the story about the child was utterly false, a modest sum of money was collected and offered by way of reparation. The men's grief at the loss of their animals was pathetic indeed.

3. When a boy in the Fourth Form at school, I always looked forward to the French lesson, as we all knew how easy it was to pull the leg of the native French master. Across one corner of the classroom was a seven-foot square black-board, and on one occasion I was encouraged to conceal myself behind it, standing on a stool, and above the top to show the antics of a toy monkey-on-a-stick. The cause of the roars of laughter was not discovered until I made an attempt to renew the game the next day, and then I learnt with painful surprise how closely my nether garment fitted. The punishment was administered savagely, and vindictive treatment was ever afterwards marked out to me by that particular master.

4. When still a boy I once spent a holiday at Saltburn, and one afternoon two entirely unassociated street musicians were standing within three yards of each other on the edge of the pavement, the one an Italian who turned the handle of a barrel-organ while a dressed monkey held out a tin can

for coppers, the other an English ex-soldier-bandsman who played a cornet. The little crowd which assembled egged on the soldier to play harder and so annoy the Italian, and the Italian's annoyance then soon showed signs of a fury that became utterly uncontrollable; foul language and a bared stiletto seemed to foreshadow an ugly finale, when two friendly policemen came on the scene and led away the two players in opposite directions, thus quickly dissolving the exciting scene.

These are the faithfully recorded memories of a boy just on the verge of adolescence, memories of observed events which made far deeper and more permanent impressions than any later printed records of the same things could have done. The writer has not known many Russians but he has been fairly intimately acquainted with many Germans, Frenchmen, and Italians, and the boyish experiences of his first contacts have always thrust themselves in front of any later and more intimate experiences. Lurking behind a German there has always seemed to be a stalking shadow of personal cruelty, behind an Italian a shadow of vindictiveness, behind a Frenchman a shadow of unforgiving hardness.

2. The Post-adolescent Convictions of the Majority.

Boys at a Preparatory School are primarily receptive, critical only in an inquiring way. From the age of about thirteen or fourteen, the critical faculty tends to develop, though very crudely up to about the age of sixteen. Gradually the wits become sharpened, and Sixth Form boys often show signs of independent thought. During the first year or two at the university there may be a set-back, stimulated perhaps by social loyalties or prejudices or by new friendships, but during the third and fourth years there are usually renewed indications of both independent and original thinking. Trained power of independent thinking is by far the greatest reward a university gives to the young men and women who spend a few years within its precincts. But the

power does not come to all of them. Too large a proportion of them are intellectual drones.

These drones scarcely rank with the other (say) ninety-five per cent of the population who never had the opportunity of going to a university; they are the world's natural idlers. The ninety-five per cent vary: some of them have done excellent work in the Sixth Form of some type of secondary school, Public or other; some have had to leave school before reaching the sixth; some have been to technical schools, many of them excellent; some to higher elementary schools, many of these also excellent; some have attended private schools, a curious survival of older days. But of all these only the few have ever become acquainted with the niceties and subtleties of language, with the history of nations other than their own, with the great discoveries of science, with the real foundations of mathematics.

And, be it remembered, education primarily connotes trained intellectual power even more than a thorough acquaintance with different departments of knowledge.

Of our former prime ministers, Mr. A. J. Balfour * was universally recognized as a man of intellectual eminence, and it was he who so forcefully pointed out that the commonly held view that the rival and opponent of authority is reason seems to most persons equivalent to a declaration that the latter must be in the right and the former in the wrong, while popular belief has driven deep the general opinion that authority serves no other purpose in discussion and speculation than to supply a refuge for all that is most bigoted and absurd.

The common opinion by which such views are supported appears to be something of this kind. Everyone has a *right* to adopt any opinion he pleases. It is his *duty* before exercising this *right* critically to sift the reasons by which such opinions may be supported, and so to adjust the degree of his convictions that they shall accurately correspond with the evidence adduced in their favour. Authority, therefore,

* later, Earl Balfour.

has no place among the legitimate causes of belief. If it appears among them it is an intruder, to be jealously hunted down and ruthlessly expelled. Reason, and reason only, can be safely permitted to mould the convictions of mankind.

Such sentiments are among the commonplaces of social philosophers, yet, when looked at scientifically, they seem to be not only erroneous but absurd. Try to imagine a community of which each member should deliberately set himself to the task of throwing off as far as possible all prejudices due to education, when each should consider it his duty critically to examine the grounds whence originate every law and every moral precept which he has been accustomed to obey, to dissect all the great loyalties which make social life possible, and all the minor conventions which help to make it easy, and to weigh out with scrupulous precision the exact degree of assent which in each particular case the results of the process might seem to justify. To say that such a community, if it acted upon the opinions thus arrived at, would stand but a poor chance in the struggle for existence is to say far too little. It could never even begin to be.—It was in this conclusive way that Mr. Balfour argued.

All authorities concur in maintaining, for example, that it is wrong to commit murder. But one philosopher tells us that it is wrong because it is inconsistent with the happiness of mankind, another tells us that it is wrong because it is contrary to the dictates of conscience, a third because it is against the commandments of God, a fourth because it leads to the gallows. Now how are we to account for this curious mixture of agreement and disagreement, for the strange variety exhibited in the premises of these various systems and the not less strange uniformity exhibited in their conclusions. Why does not as great a divergence manifest itself in the results arrived at as we undoubtedly find in the methods employed? How is it that all the different explorers reach the same goal when their points of departure are so widely dispersed? Plainly there is only one method of solving the

difficulty. The conclusions were in every case determined before the argument began. There was no surrender of belief to the inward guidance of unfettered reason. Rather is reason coerced to a foreordained issue by the external operation of prejudice and education, or by the rougher machinery of social ostracism and legal penalty.

The only results which reason can claim as hers by an exclusive title are of the nature of logical conclusions, and rationalism is not, as Mr. Balfour so tellingly pointed out, a logical conclusion but an intellectual temper. The only instruments which reason, as such, can employ are arguments, and rationalism is not an argument but an impulse towards belief, or disbelief. So that though rationalism is doubtless due, among other causes, to reason, it is not on that account a rational product, and though in its turn it produces beliefs it is not on that account a rational cause.

Persons with untrained minds always seem bound to adopt some belief concerning any topic which comes much before them. It has been trenchantly remarked that if we can only get any average Englishman to consider whether rabbits in the moon have blue tails he will soon have an opinion about it. It will be difficult to make him think, but if he does think he cannot rest in a negative and will come to some decision. And on an ordinary topic, of course, it is so. An ordinary tradesman has a full creed as to foreign policy, an ordinary church sacristan has a complete theory of the church sacraments, and on these respective things neither has any doubt whatever.

3. Convictions and Opinions: Persuasion and Prejudice.

It has been well said that the power of an idea to cause conviction, independently of any intellectual process, largely depends on clearness. The more unmistakable an idea is to a particular mind, the more is that mind predisposed to believe it. In ordinary life this is exemplified constantly. If we ever make a thing quite clear to a person, the chances

are that we shall almost have persuaded him of it. How true is the old adage that the majority of men only understand what they believe and always believe what they understand!

If we desire to persuade others, it is advisable to avoid the appearance of deliberately attempting to work upon their feelings. For this reason the emotional appeal of persuasion is generally made by the practised orator more or less indirectly, through the imagination and intellect.

No one who has had real passionate conviction that burns hot in the brain can ever be indifferent to that creed again. He simply cannot forget it.

It is easy to distinguish the *words* prejudice and reason, but it is difficult to separate the two *things* they signify. Reason seems a very positive and palpable thing to those who have no notion of it except as expressing their own views and feelings; and prejudice always seems to be an inexcusable absurdity as long as we continue to apply this term to the prejudices of other people. Prejudice is properly an opinion engendered by feeling, not for which there is no reason but for which we cannot render an immediately satisfactory account. It is not always possible to assign a reason for the faith that is in us, but it does not therefore follow that our faith is hollow and unfounded.

There is a common type of mind which gives an intellectual assent to conclusions though feeling no strong faith in them, and often does not know what its real opinions are. Every day the person has to go over the arguments again, or even to refer to a note-book to check what he believes. But intense convictions make a memory for themselves, and if they can be kept to the truths of which there is good evidence, they give a readiness of intellect, a confidence in action, a consistency in character, which are not to be had without them.

It is certainly true that many conclusions which are by no means self-evident, and which are gradually obtained nevertheless, are not the result of discussion. For example,

the opinion of a man as to the characters of his friends and acquaintances is not the result of distinct agreement, but the aggregate of distinct impressions; it is not the result of an investigation consciously pursued, but is the effect of a multiplicity of facts involuntarily presented; it is a definite thing and has a most definite influence on the mind, but the origin is indefinite and not to be traced.

The term belief includes an intellectual element we call assent and an emotional element we call conviction. The laws of the intellectual element in belief are the "laws of evidence" and have been elaborately worked out, but those of the emotional part have hardly been seriously discussed at all. In the mind of a rigorously trained inquirer, the process of believing seems to be this: first comes the investigation, a set of facts are sifted, and a set of arguments weighed; then the intellect perceives the results of these arguments and assents to it. Then an emotion more or less strong sets in, which completes the whole. In calm and quiet minds the intellectual part of this process is so much the strongest that they are hardly conscious of anything else; and as these quiet careful people have written our learned treatises, we do not find it explained in them how important the emotional part is.

Amongst the uneducated and ill-informed strata of society, beliefs tend to differ fundamentally, but at the top they tend to agree. As society advances, the standard of beauty, of morality, and of religion, tends to become fixed. The creeds of the educated and well-informed classes throughout the world, though far from identical in these respects, are not entirely unlike, approach to similarity more and more as education advances, as virtue develops, and as disturbing agencies tend to dissolve.

So long as there are earnest believers in the world, they will always oppose those who differ in opinion from themselves, and some of them will be quite unscrupulous in the methods they employ in converting such opponents. It is probably true that Hitler is profoundly convinced that the

Germans are the ablest and most industrious people in the world, and that therefore it is his duty to sweep aside all opposition both to their world leadership and to their world ownership. But oh

“ That he could look at true things
And, unillusioned, *see* things ”!

CHAPTER II

Science in the Dock: the Case for the Prosecution

Why is it that science is now so strongly manacled as it stands in the Dock? Let us listen to the charges brought against it by the prosecuting counsel:

It had become the custom to apply the term "Public Enemy No. 1" perhaps to an American "gangster", perhaps to an elusive international criminal, perhaps to the chief of a Totalitarian State; but during the last few years the term has been applied more and more to the abstract term *Science*. Science is now often credited with being the root cause of all the world's major evils, inasmuch as it has acquired enormous power and uses it callously and cruelly and with an utter indifference to human suffering; it acts like a wayward child, though fully aware of its great responsibilities; it is the focus of public opprobrium, but the opprobrium is expressed in whispers, for all the world is a-tremble, wondering if the new fiend which now so boldly stalks abroad is the master-devil himself in a new guise, busily engaged in his preparations for the utter extinction of civilization.

The charges made against science seem to be irrefutable when examined in the light of the conduct of modern war. Here is a quotation from an ordinary standard textbook in chemistry: "It is safe to say that the progress of civilization may be measured by the increase in the annual consumption of sulphuric acid." Think of it: a destructive burning liquid a measure of *civilization*! Here is a second quotation, from a modern infantry manual: "You are attacking a highly civilized enemy, who may therefore be expected to

use gas." Note the word *therefore*!! What the writer probably *meant* was an enemy highly equipped with scientific means of destruction, but what he *says* is that because the enemy is *civilized* he will therefore use gas. And here is a third quotation, this time from a statement made by Bruno Mussolini, the son of the Italian Dictator: "It is difficult to describe the exhilaration one feels in dropping a 2000-lb. bomb and watching its effect." Mark the word *exhilaration*! exhilaration at having brought about the utter destruction of perhaps a great hospital full of the sick, the wounded, and the dying; of perhaps a school containing a thousand innocent children, of perhaps a church with its multitude of worshippers. Mr. Bertrand Russell quotes the same Italian leader's account of his exploit from the air in the Abyssinian war: "We had to set fire to the wooded hills, to the fields and little villages. It was all most diverting. 'The bombs hardly touched the earth before they burst out into white smoke and an enormous flame and the dry grass began to burn. I thought of the animals: God, how they ran. . . . After the bomb-racks were emptied, I began throwing bombs by hand. It was most amusing: a big Zariba surrounded by tall trees was not easy to hit. I had to aim carefully at the straw roof and only succeeded at the third shot. The wretches who were inside, seeing their roof burning, ran off like mad. Surrounded by a circle of fire, about five thousand Abyssinians came to a sticky end. It was like hell."

Then we read of the machine-gunning of street-crowds, and, perhaps worst of all, soldiers chuckling over their evening meal at the memory of the tortures they had inflicted earlier in the day on their fallen enemies writhing in their poison-gas death throes. The infliction of such horrible cruelties is bad enough, but that civilized soldiers should boast of having perpetrated them is horrible indeed. Happily, British soldiers have never yet descended to such depths, but, like their enemies, they are earnest students of science, and who is to say what the ultimate effect on them may be?

Then, again, science was responsible for the industrial revolution a century ago. Britain, with her great supplies of coal and iron, was spurred on by a handful of capitalists and exceptionally resourceful inventors, and soon found herself mistress of most of the great markets of the world. But the wholesale introduction of machinery displaced a vast amount of labour; the few piled up vast fortunes, the many became impoverished. The clever craftsman has gradually become displaced; his successor is a machine-oiler and a switch-attendant; there is no longer any reason why such a man should think seriously about his work, and he has become bored and disgruntled, perhaps even a workshop centre of radiating discontent. Sir Alfred Ewing, who certainly ought to know, speaks thus:

“More and more does mechanical production take the place of human effort, not only in manufactures but also in all our tasks, even the primitive task of tilling the ground. So man finds this, that while he is enriched with a multitude of possessions and possibilities beyond his dreams, he is in great measure deprived of one inestimable blessing, the necessity of toil. We invent the machinery of mass-production, and for the sake of cheapening the unit we develop output on a gigantic scale. Almost automatically the machine delivers a stream of articles in the creation of which the workman has had little part. He has lost the joy of craftsmanship, the old satisfaction in something accomplished through the conscientious exercise of care and skill. In many cases unemployment is thrust upon him, an unemployment that is more saddening than any drudgery. And the world finds itself glutted with competitive commodities, produced in a quantity too great to be absorbed, though every nation strives to secure at least a home market by erecting tariff walls.”

Science is constantly boasting of the benefits it is conferring on the poor; why then the world-wide impoverishment, hunger and mal-nutrition, and almost universal discontent? Why does science produce year by year huge gluts of food that are never consumed, when prices are so heavily loaded against the consumer? Is it not wanton for

science to stand idly looking on when twenty-seven million bags of coffee are burnt in Brazil, when millions of acres of cotton are ploughed up, when millions of young pigs and hundreds of thousands of prospective mother sows are slaughtered, when hundreds of millions of unsold herrings are thrown back into the sea? And yet science is ever boasting of the further industrial revolutions which she hopes to bring about, for example by the transmutation of metals, when the world's hoards of gold will be worth their weight in old iron; by the release of sub-atomic energy, when available supplies of power will be increased a hundred thousand times (we are seriously told to picture a bomb which will blow the British Islands half-way across the Atlantic); and by the invention of new fabric-equivalents which will put on the scrap-heap every spinning and weaving machine in the world, and throw on the labour-market millions upon millions more of unemployed. Science professes to be rather ashamed that we still spin and weave animal and plant fibres, in much the same way as our remote forefathers did a hundred thousand years ago; we have speeded things up a little, that is all. Assuredly science is one of the chief sources of social unrest, for she is constantly increasing the powers of production, and to such an extent as to suggest the possibility of something like at least moderate wealth for all, and yet this wealth seems farther away than ever.

Then there is the modern invention of "radio", at first thought likely to prove an inestimable blessing to the whole world. But there came the time when one of the Dictators desired to make his people believe that the British were the most contemptible race on the surface of the earth, and he selected his country's arch-liar to set forth to the German people, day in and day out, through their wireless sets the villainies, the crimes, and the obnoxious personal equations, of the British people. Any little fact that told against them is multiplied a hundred-fold, any in their favour is totally suppressed. These grossly distorted accounts have been ringing in German ears for almost a decade, and they act on the

mind like a subtle drug on the body, a strong daily dose of which the people have learnt to clamour for. In this way the Germans have been taught to hate us, even to loathe us, and perhaps worst of all to despise us. And it is very sad to think that the chief man whom Herr Hitler employs to do this daily radio work is a renegade Englishman. Herr Hitler's personal views are only too well known. In *Mein Kampf*, he says, "propaganda which is skilfully thought out and persistently administered can make hell seem like heaven and heaven like hell," but it is science that he so skilfully and regularly employs to do the administering.

In its zest for making new discoveries, science is admittedly sometimes coldly and calculatingly cruel. The vivisection of dogs and other live animals in medical research laboratories is still practised, though now under official control. And there are whispers of indescribable horrors in German concentration camps, where science can work its wicked will in secret.

It is gravely doubtful if scientists as a class can seriously claim to be educated. To be successful in the special field in which they have chosen to work, they are bound to devote practically all their time to it. They are often singularly lacking in culture, amazingly ignorant of history except the bare outlines of that of their own country, and almost indifferent to the humanities. If they express an opinion on social or political matters, they are almost unheeded.

Worst of all, perhaps, science has become the arch-enemy of the Christian faith. Until Galileo dethroned the earth from its primary position in the universe, the simple faith of the ancient and the mediæval Christians was based on a whole-hearted acceptance of the Bible as an inspired book. During the centuries which have followed, science has been attacking the Bible and all it stands for. Not a few educated people have surrendered their faith altogether, and certainly a great majority of them have become at least modernists in some form. Of the great masses of the people whose claims to be educated are only slight, some have be-

come utterly indifferent to the Christian religion, others are loyal but have lost their enthusiasm, others, perhaps the largest number, are desperately unhappy. This indifference comes about partly because science refuses to credit certain fundamental articles of the Christian creeds, e.g. the virgin birth and the resurrection of the body; and partly because in its reference to the Bible it sometimes uses language which tends to wound, e.g. it speaks of "a chattering snake" in the Garden of Eden, of "the chemical conversion of Lot's wife into a common chloride", just as if the conversion took place in an ordinary laboratory; of the enforced voyage of "Jonah in an ancient submarine", of the Gadarene "pigs". Cannot science at least use the Biblical language which we know and which we treasure? As for the three Christian creeds, do not all clergymen of the Church of England when they take orders solemnly subscribe to the thirty-nine Articles of Religion, and does not the eighth Article assert that the three creeds "ought thoroughly to be received and believed, for they may be *proved* by most certain warrants from holy scripture"? Science boasts that all its principles and laws have been rigorously reasoned out from sifted and verified facts, but who will dare to deny that the intuitions of saintly men are both infinitely more worthy of credence than the a-moral hypotheses reasoned out by science from groups of icily-cold facts, and may be readily adopted as a final criterion of truth? Science even goes so far as to attack the Philosophers' Absolute, but does its equipment give it the slightest claim to approach the solution of this final problem of the philosophers?

These, said the prosecuting Counsel, are my charges against Science. Is there any reply?

Before the many charges can be adequately met and the defence be properly understood, the reader must make himself familiar not only with the nature, scope, and general trend of modern science but with the general method of scientific workers, and to these things we devote the next two chapters.

CHAPTER III

Science: the Vast Field it now Covers

1. The Science of the Nineties.

As recently as the nineties, science covered a field of very moderate extent. The headquarters of British science teaching were at South Kensington, and from there some twenty-odd differentiated syllabuses of instruction were issued. They were then fairly complete, but how trivial, indeed how antique, they all seem now! A student who took the Natural Science Tripos at Cambridge, or a pass Degree in science at London, devoted three years to the study of three different subjects, perhaps physics, chemistry, and mathematics, or some softer option such as geology, botany, and zoology, and in that time was able to acquire a knowledge of most of the essentials of each. A professor of, say, physics, or of biology, was supposed to be master of his whole subject, and not of just one small part of it as now. It is pretty safe to say that the field of present-day science is at least a hundred times as extensive as it was fifty years ago. No one man can now make himself master of the whole. The most he can do is to make a fairly exhaustive acquaintance with one small subject, a general acquaintance with the more closely related subjects, and to take an ordinary layman's interest in all the rest.

Oddly enough, however, it is by no means impossible for an intelligent layman to make himself familiar with large parts of this vast field, especially if he was fairly well-grounded in school science when a boy. Well-illustrated and simply and accurately written textbooks in every branch of science are now abundant. The layman need not worry because such textbooks contain so little of the technical

language of science, inasmuch as the technical terms are very largely concerned with "theory", the greater part of which is bound to remain outside a layman's ken. A scientist is usually compelled to invent a new term for a new idea; if he used an old word, the old associations of that word could not be shaken off, and ambiguity would be inevitable. There are, however, multitudes of terms quite easy to understand.

2. The Mathematical Part of the Science Field.

The layman who decides to explore the field may at first be a little repelled because parts of it seem to be highly mathematical. This, however, need not deter him at all. If he was at school within the last thirty or forty years, he will know enough arithmetic, algebra, geometry, and probably a little trigonometry, mechanics, and higher work, to be able to follow up the reasoning underlying many physical problems. Not all, of course; there are now involved in both physics and in other branches of science mathematical principles of so high an order that only really competent professional mathematicians can master them. But in point of fact much of the mathematics of science is very simple, though its simplicity is concealed in a symbolism which is imperfectly understood. We may cite a single example.

On 6th April, 1940, Admiral Beadnell wrote to *Nature*, referring to a difficulty he had experienced in connexion with the estimate of the mass of the universe. He said: "Eddington gives the mass of the universe as 10^{22} stars averaging our sun in weight. Taking 2.0×10^{27} tons as the sun's weight, then the mass of the universe would be 2.0×10^{49} tons". The admiral asked if this mass was not too low: should not the radiation from all the stars be added? In a courteous reply Sir Arthur cleared up the admiral's difficulty.

Rather mischievously, perhaps, I took the question to four distinguished men—a biologist, a consulting physician, a philosopher, and a classical scholar. I told them that I knew how the weight of the sun and how the number of stars had been determined, but could they explain to me the real

significance of the figures, and help me to form a clear conception of such vast numbers and such stupendous weights? I soon found that the quoted statement left them all quite cold and made no sort of intellectual appeal; they made no attempt to transform the words into a clearly visualized picture. One thought that the 10^{22} stars had been actually counted: "It could not be so very difficult if the dome of an observatory were covered with a network, and if the stars seen through each opening of the mesh were counted separately!" Another: "Oh, that's mere mathematics; it is only a question of working out." Not one of the four could take himself back to his old Form IV days.

(At the end of the chapter * we append a note which may be useful to readers whose arithmetical sense has not quite faded away.)

3. A Brief Summary of the Field as a Whole.

(i) *Mathematics*

In the old days mathematics claimed to be "the queen of the sciences", inasmuch as she never made mistakes; mathematical reasoning was considered to be absolutely flawless. She claimed to be above all things logical, and the first principles from which she reasoned were embodied in a number of *axioms* which were regarded as unassailable basic truths. But most of these old axioms have now been thrown to the wolves, and mathematics, like every other branch of science, is expected to search for and to verify its basic facts. Its main business is counting, measuring, and weighing. It even claims to count the stars, but it is impossible to do this directly, the main facts being inferential; it counts molecules, but again only by inferential methods. As for measuring, how are we to measure anything with absolute accuracy? With a finely divided scale, we may measure the length of a line to within the hundredth of an inch, but the very marks on the scale itself have a width of their own, this also applying, of course, to the ingenious device, the vernier. Screw gauges

* See p. 32.

and other devices are of the greatest service, but nevertheless science has so far failed to measure or weigh *accurately*. How are we to measure the circumference of a circle in terms of the diameter? It simply cannot be done.*

If we are rash enough to accept a mathematician's first principles commonly called axioms, many of his propositions can be proved, and proved rigorously. A familiar example of rigorous proof is seen in the proposition that the angle in a semi-circle is a right angle. But this proof depends upon our acceptance of the assumption that a semi-circle is part of a plane surface. Where, however, in nature, are we to find a plane surface? The surface of the earth is certainly not plane, it is spherical, and the sum of the angles of a spherical triangle is certainly not two right angles, so that the proof in question is fallacious. There are, however, some propositions which we *believe* to be true but cannot prove. For instance, every mathematician is "quite sure" that only four colours are necessary to colour a map, no matter how complicated a system of divisions the map may contain. This is just an article of faith, though of a very robust kind. No *proof* has ever been discovered.

The essential difference between mathematics and the various branches of natural science is that it is essentially an *abstract* science. Every branch of science selects certain aspects of nature for its own study and neglects everything else, i.e. it *abstracts* for its own particular purpose. If a mathematician decides to measure up the planet Mars, he does not trouble whether Mars is inhabited, he sees just a spherical area to be measured and a mass to be weighed, and he sees nothing else. The facts with which he concerns himself may be of a highly complex character, but he is often able to weave them all into an innocent-looking algebraic equation. Einstein did this not merely with Mars but with the whole universe, and with such marked success that his brother mathematicians all over the world rubbed their eyes again and again.

* See *Obsessions and Convictions of the Human Intellect*, Chap. VI.

(ii) Physics and Chemistry

Physics and Chemistry were formerly quite separate and distinct subjects. Physics included various branches of study—Sound, Light, Heat, Electricity and Magnetism, Work, Energy, Power, Force, Hydrostatics and Hydraulics, and others. The basic distinction between physics and chemistry was that physics concerned itself with the properties of substances down to the smallest natural particles, viz. *molecules*, but not with the composition of the molecules; the composition and the architecture of these molecules, that is the *atoms* and their arrangement within the molecules, was the business of the chemist. The physicist might apply heat or cold to some substance, say water, and change its form to steam or ice, but the water molecules remained water molecules all the time. The chemist, on the other hand, would break up these molecules of water into atoms of oxygen and hydrogen, and perhaps combine them in new ways to make new compound substances. To the physicist, sugar dissolved in water remained sugar all the time; it had simply broken up into its natural molecules which, though very far below the range of vision, could easily be recovered in the form of visible aggregates.

Half a century ago, the chemist believed his atoms to be the final and indivisible particles of substances. Each of the ninety-two elementary substances was supposed to be ultimately composed of atoms peculiar to itself, the atom of every substance being hard and spherical, quite unlike the atom of any other substance and having a characteristic invariable weight. In more recent years, physicists helped by chemists, have shown that atoms are not simple but composite, all ninety-two being made up of the same ultimate constituents, viz. electrons and other particles, these varying in number according to the particular atom. The essential difference between, say, gold, iron, sulphur, and chlorine, is merely a *numerical* difference, a basic fact which the untrained layman cannot hope to understand.

(iii) *Heat and Mechanics*

Between them, Heat and Mechanics (we use the terms in the widest sense) cover a very considerable portion of the scientific field—the steam-engine, the internal-combustion engine, the Diesel engine, fuels, heat transfer, cold storage and the artificial production of refrigeration, the compressed air Greathead shield for boring underground tunnels (it is possible to bore from opposite ends of a proposed long tunnel and meet in the middle accurately to $\frac{1}{8}$ inch), the harnessing of water-power for the production of electricity, engineering work in the construction of roads, canals, railways, bridges, harbours, ships, motor-cars, air-planes, and a hundred other things. Think of the amazing ingenuity of such an inventor as Edison! Few inventions strike the imagination more than the ultra-centrifuge, a wheel about 2 inches in diameter, invented by Svedberg and others at Upsala, which had its origin in the common cream-separator of our dairies. Its rotating wheel can spin up to 140,000 times a minute, and if a liquid is put in special cells bored in the wheel, a separating force is produced equal to 700,000 times the force of gravity. Needless to say such a thing must be enclosed in armour-plate and is very costly, but it is invaluable for throwing out from solution, for isolation and experimentation, the invisible particles of certain diseases, just as particles of cream are thrown out of milk by the common separator. Another remarkable invention is that of a Swiss watchmaker who has made (April, 1940) an electric motor which weighs the tiny fraction of a gramme and is enclosed in a pearl! Science? Perhaps not, and we may regret that so much patience and ingenuity were not diverted into more useful channels.

Closely associated with engineering are the production of power, the production of new materials and new processes, the search for new mineral resources, deep-shaft mining, smelting and metallurgical processes. Then there is aviation, which originated less than forty years ago with the brothers

Wright who, in 1905, startled the world by keeping up in the air for thirty-eight minutes; the first non-stop flight across the Atlantic was made in 1919. How many planes does the world possess now? half a million? The wonderful technical developments of the last few years, and the advance in aerodynamics as a science have been amazing. Is there really any limit to speed?

(iv) *Electricity*

When we come to Electricity, the developments of the last forty years seem almost endless—generators, transformers, distribution, storage, the electrification of industry and of the home, heating and lighting—a large volume might be written on any one of these things. Then there is “wireless”, the most interesting fact in the history of which was the general baffling of the world’s physicists and mathematicians by Marconi when he surmounted the 125-mile-high spherical segment forming the ocean-hump between Cornwall and Newfoundland. How was he to plan a straight route for his electric signals? he simply didn’t try. Then, again, there are X-rays and Radioactivity. How the present writer treasured his first Crookes’ tube half a century ago, though he never dreamt what it was to lead to. Röntgen came along in 1895, and discovered unknown rays (X-rays) emerging from one of the tubes, and, by means of them, certain important phases of surgery were soon to be revolutionized. Becquerel and the Curies followed up, and a little later, our own genius, Rutherford, with his radioactive transformations and his exploration of the atom, continued the wonderful pursuit.

(v) *Light*

Light, once regarded as an independent branch of physics and as a simple thing, is now known to be a sort of twin-sister of electricity, though eminent authorities are still at variance about the actual relationship. But we have learnt to press it into our service in many amazing ways. At the moment

television is an infant, but a score of years hence or even less we shall be able to see and hear everything that is going on in every part of the world, and ultimately, perhaps, in any part of the universe. How we are inclined to wish that we might have lived a thousand centuries hence! We should not, however, lose sight of the development in the power of the common optical instruments. Every increase in the power of the telescope shows us a still bigger universe, and we are all looking forward to the completion of the 200-inch reflector in America, but the slow cooling of the huge mass of fused quartz is a very long and tedious process. Some years must still elapse before the instrument is ready for use.

(vi) *Chemistry*

We have seen that Chemistry and Physics have become closely allied subjects, and advanced students of either may be heard discussing such things as "nuclear spins", "valency angles", and "energy levels", but these academic terms are bound to remain mere nebulosities to the layman, and they are certainly not always free from mist when on the lips of the professional scientist. It is the practical side of the chemist's work that is so interesting and valuable. Not the least important of his manifold activities concerns our food and food supply—food products, digestion of food, the safe-guarding of the purity of food. But there is a veritable multitude of other things: water-softeners, the purification of our water-supply, the dealing with factory effluents into rivers, sugar and confectionery, drugs, dyes and perfumes, paints, colours and varnishes, cleansing agents, non-ferrous metals and high-speed steel, photographic emulsions, utilization of by-products, improvement of industrial processes, and the provision of new materials, especially as regards increase in lightness, strength, elasticity, toughness, hardness, &c. The chemist is researching in all sorts of useful directions, e.g. into the making of non-inflammable films and creaseless cotton fabrics. But by far the most valuable work he is doing at present is that associated with some form of

biology. In fact, bio-chemistry is a newly forged link connecting the two subjects.

(vii) *Biology and Allied Subjects*

Fifty years ago Biology was the Cinderella of the scientific world, but the work of men like Darwin and Huxley had done much to make thoughtful men see something of its fundamentally important character. In schools, the subject was scarcely touched, except that in girls' schools Botany received some attention, chiefly in the form of nature study, with a few odd experiments on transpiration, respiration and photosynthesis; and, in the course of work for boys hoping to enter on a medical career, the study of a few animal forms and the use of the microscope were included. Zoology was usually associated with interesting afternoon visits to the Zoological Gardens; Physiology was rarely even mentioned.

And now? Biology stands in the very forefront of the various branches of science.

Both the animal and the plant, even the most lowly of them, are now known to be living machines, all of the most amazing complexity, all of them far more perfect than the most perfect piece of mechanism ever constructed by man.

The lowest form of life consists of a single cell, but any form above this consists of a multitude of cells. The body of a human being or of any ordinary animal consists of many millions of cells; so does any tree or plant. The cells can be easily seen as a kind of close network if a thin section of, say, an ordinary plant stem is placed under the microscope. Every one of these cells is a perfect physical, chemical, and biological laboratory, making new substances from the food and water supplied to it, co-operating systematically with its neighbours, acting as a chemist and as an engineer in a way which no man is able to imitate. In the centre of each of these cells is a number of threads called chromosomes (i.e. "coloured bodies", so-called because they are readily stained under the microscope and then easily seen), and these chromosomes are believed to be made up of a multitude

of elementary units, called "genes", far below the limits of microscopic vision, each gene being distinct from all its neighbours, and doing the special work assigned to it. Although the existence of these genes is still a little doubtful, the special study of the chromosomes is called Genetics, and there is no doubt at all that, within these chromosomes, most of the secrets of all living processes are contained. The process of Evolution is now admitted to be a fact, but how has it been brought about? We do not know, but we are certain that the secret is within the chromosomes. We do not yet know much about Heredity, but we are certain that the secret is also within the chromosomes. Some enthusiastic geneticists believe that the secret of life itself is also to be found within the chromosomes. *Perhaps!*

The chief work of Bio-chemistry is concerned with nutrition and food-values, and for years bio-chemists have been devoting special attention to vitamins and hormones: the distinction between these is mainly place of origin, the vitamins being absorbed from an extrinsic source, and hormones being produced by the living organism itself. The hormones seem to be the organizers of all the bodily activities, but the organizer of the organizers—who, what, and where is he? Then again, all over the world there are large numbers of earnest workers engaged in Bacteriology, in Tropical Medicine, in Preventive Medicine and Medical Research, in Radiology, in Endocrinology. Several dread diseases have been mastered during the last thirty or forty years, and though cancer stubbornly refuses to give up its secret, research is bound to discover it some day. Still another biological subject is Agriculture, and what a great subject it is, dealing as it does with farm animals and poultry, farm and garden crops, insects and pests, economic entomology, soils and plant nutrition, plant breeding, plant physiology, animal nutrition, animal breeding, animal pathology, dairying, and agricultural research generally. Rothamsted is a world-famous agricultural research station.

(viii) *Geology*

Still another subject occupying the attention of many eminent men is Geology. It is perhaps 10,000 million years ago since a passing star attracted from our sun a millionth of its mass, and sent it spinning into space as a huge sphere of gas which gradually cooled down, liquefied and solidified, and formed the earth, the heavier materials sinking centrewards and the lighter remaining at or near the surface. The surface of the solidified shell tended to crack and to crinkle as the molten liquid interior continued to cool, and the water that had been formed collected in the surface hollows. Geologists have long been busy investigating the nature of this outer up-and-down and often topsy-turvy crust, in which they have discovered a large number of useful minerals and metals. They cannot at present get down into the interior more than a mile or two, boring is so expensive, and the heat is so great. But deep-shaft mining is a thing of the early future, and when, as time goes on, we can use the vast stores of the earth's interior heat, an almost unlimited supply of power will be available. Other still unused sources of power are the winds (we do drive a few windmills, and we still have a few sailing-ships!), the ocean currents, and the tides. Think of the vast supplies of water-power to be had for the asking, did we but know how to use it. The earth is gradually being reduced to a dead level, for the time is bound to come when internal shrinkage and upheaval, due to the cooling down of the interior, will necessarily end. But that time is not yet. How little we yet know of submarine geology, and what valuable secrets may still lie unrevealed in the ocean beds, but the Coast and Geodetic survey of the United States is certainly not idle.

When the infant earth had cooled down sufficiently, life seems to have appeared, though how we do not know. Doubtless its first forms were of a very lowly character, but development proceeded apace, and species after species appeared, the last being man himself. If evolution is a fact, as presum-

ably it is, it would be rash to assume that man is nature's final product. We may well wonder what our successors of a hundred million years hence will be like. Not all the earlier forms of life have taken part in the course of evolution; the little *Lingula*, for instance, seems to be nearly the same now as its ancestors many millions of years ago. Anthropology is busy trying to find the missing links in the long evolutionary chain of which man is the last link. Many of these missing links have been unearthed in different parts of the world, as fossils and other types of preserved specimens in our museums testify. The basic facts upon which the anthropologist works are the facts of evolution and of inheritance; but perhaps the greatest fact of all in biology is that of communal life, not only as presented by colonies of insects like bees and ants but also as presented by cell communities constituting the bodies of all animals and plants. The communities seem to work in perfect harmony, as if under the control of a master-hand. *How* evolution arose is still a matter of dispute, though the new science of genetics may some day be able to decide between the rival hypotheses. Was the transformation from species to species sudden or gradual? that is the main question. We must balance the evidence provided by Darwin, Mendel, and Lamarck, and draw our own conclusions. When did a bird's wing first appear? When the shelled egg? When the lung? Why? How? What was the *purpose* of evolution?

(ix) *Astronomy*

What a small subject Astronomy seemed to be in the eighties and nineties. One could master the whole subject within a year, though it is true that we knew almost as much about the sun and the planets as we know now. But Norman Lockyer and his co-adjutor Richard Gregory were at work at South Kensington and preparing the way for greater things. What an insignificant thing the universe of those days now seems to be! It was less than 3000 million miles to Neptune, the most distant planet. And now? Already we

know the universe to be so vast as to be utterly beyond our imagination. Light, travelling at the rate of 186,000 miles a second (this preliminary fact requires much grasping), takes *a million years* to come to us from some of the distant stars, and those are by no means the most distant of all. In the race of astronomical discovery, America will be the winner. She has that huge 100-inch telescope in California, and she has in the making one vastly bigger still.

4. Science and the Future.

Our very limited space forbids more than this very incomplete outline of the huge field now covered by science. Hundreds of thousands of intelligent men and women are devoting their lives to the subject, tilling, sowing, and reaping, nearly all of them hoping to benefit in some way the human race and to further the interests of civilization. How very few of them, if any, have ever seemed to be planning any sort of mischief! And if we visit the various departments of the great Research Institutions, whether under the Government or under a university, say, the Department of Scientific and Industrial Research with its numerous stations, the National Physical Laboratory at Teddington, the Cavendish Laboratory at Cambridge, the Imperial College of Science and Technology at South Kensington, the Rothamsted Agricultural Station, and dozens of others, it is always the same story, viz. the search after knowledge and the hope of contributing to human happiness.

And the future? Mr. H. G. Wells' forecasts have always seemed a little uncanny, but how often his pointers have proved correct! It is sometimes forgotten that in his early manhood Mr. Wells was a brilliant student at the Royal College of Science, and that he does really understand, none better, what he is talking about. It is true that, so far, we have not been invaded by the Martians, but shall we ever be able to invade them, or at least to pay them a friendly call? The planet is only some 40,000,000 miles away, a mere bagatelle in these days of powers and speeds. Is the germ of the idea

to be found in the success of the American Professor Goddard's rocket? Professor Goddard is the well-known authority on the exploration of the upper atmosphere, and his calculations show that it ought to be possible to convey a pound of magnesium flash-powder to the surface of the moon, and watch its ignition through a telescope on the earth. In his experiments with rockets, he succeeded in producing a speed of some 10,000 feet a second, i.e. four times as fast as the initial velocity of a bullet leaving a rifle. If this velocity of over 7000 miles an hour could be maintained, a projectile might reach the moon in less than two days. It is not, of course, proposed that the first rocket sent to the moon shall be manned, and it will be a long time before space-ships will be available for making lunar pleasure-excursions, though, once there, we may be able to refuel and set out on the longer journey to Mars! But that is not yet. Unfortunately, the Martians did not tell Mr. Wells how they overcame their own gravitational pull-back, or how they retarded the earth's pull-downwards.—All this may sound fantastic, but science is quite confident that journeys in inter-planetary space will be made within the next century or so.

There are one or two eminent biologists who are confident that science of the future will succeed in doing a still more wonderful thing—produce a laboratory-made live man. One thing that seems to inspire them with confidence is the work of another American, Professor Carrel, who has succeeded in keeping alive, for many years, in the famous Rockefeller Institute a bit of chicken-heart. This chicken-heart is carefully looked after, day in and day out, by trained attendants, and is regularly fed and cleansed, and there seems to be no reason why it should not live for another century. But Professor Carrel did not *make* the bit of chicken-heart; nature did that for him, and no biologist has ever yet succeeded in making any sort of material which contains *life*, to say nothing of a complete living plant or animal. Let us assume that some day he does contrive to construct a man architecturally and anatomically perfect down to the last molecule:

how will he set the machine in motion? How will he make it *live*? How will he make it *conscious*? How will he make it *think*? Psychology may eventually be able to give him a hint or two, but it certainly cannot do so yet.

What science may do within the next century, within the next thousand years, within the next million years, if civilization survives, it would be folly to try to guess. It is more to the point to measure the rate of progress of the present day. Medicine, for instance, is making rapid strides, and it is pretty safe to hazard that fifty years hence drugs will be very rarely used. Though there is still a vast amount to learn, a great deal is now known about the human body as a working machine and as a complex system of physical and chemical laboratories, and new curative treatments are rapidly being introduced. What is sometimes called physical medicine, or physio-therapy, includes treatment by massage, electrical treatment of many kinds, heat, hydro-therapy, therapeutic exercises, remedial games, radiant energy, occupational therapy, and manipulative surgery. These things form a fairly accurate index of the sort of work which the next few years will see developed on an ever-increasing scale. And psychology is rapidly becoming the medical practitioner's chief handmaid. But the practice of medicine is still very far from being a science; it remains an art, and the medical man's intuition still plays a large part in his daily work.

Despite the difference of scale, some idea of progress during the present century may be gauged by comparing, say, a fifty-year old paddle-wheel coastal steamer and a great modern liner. A single minute will suffice to examine the old engine-room of the former and all that therein is. And the huge modern liner? Make friends with one of the engineers and get him to show you something of the ship's amazing engines, machinery, and mechanism. Ask him to show you how the 100,000 boiler-tubes are supplied daily with pure water. Where are all the grimy sweating stokers of the old days? How is the 200,000 horse-power developed? An

enormous amount of work is done by electricity, the wonderfully complex installation of which would make that of any small town blush. Look at the engineer's recording-board with its hundred instruments—pressure gauges, revolution-recorders, inclinometers, oil-pressure measurers, vacuum gauges, voltmeters and ammeters, thermometers, &c., &c. The engineer sees instantly if anything is going wrong.

Examine the surface of a modern gramophone record which reproduces perfectly, say, some famous symphony as played by an orchestra of a hundred instruments. The record is now made automatically while the orchestra is playing, but is this elaborate plan really necessary? Will not the time come, and come soon, when a musical composer, having completed a composition, will pass it on to a specially trained mechanic in dot-and-dash recording and get him to prepare a gramophone record? Will musical instruments themselves then be any longer necessary?

Such a mechanical scheme is apparently *possible*, but its adoption is perhaps hardly likely. Consider, however, a plan of a totally different character. Our leading authorities on nutrition are rapidly discovering exactly what substances and how much of them are necessary to keep the human body as a machine in perfect going order, and we know that everything we take in beyond this amount is sheer waste and is eliminated. Will science ever teach us exactly how to confine our consumption to bare necessities, which are known to be extremely small in amount, and induce us to allow our alimentary canal and its attendant satellite glands to fade away nearly to nothingness? Think of the opposition from the millions of food producers, and from those who delight in the pleasures of the table!

Some readers may be inclined to consign all such schemes—and there are multitudes of them—to the limbo of lunacy, and perhaps rightly. And it must be borne in mind that while science believes many things to be theoretically *possible*, we may be quite sure that in actual practice they must be ruled out of court, even in the far future.

It is, however, very hazardous to prophecy. For instance, shall we ever be able to tap the vast resources of the earth's interior, or even of the ocean floor? to divert ocean currents? to regulate the climate? to rid the world of all pests which ultimately are responsible for diseases? "You never can tell."

Let us carefully bear in mind that science asks the questions *What?* *Whence* and *Whither?* and *How?* But it shrinks from asking *Why?* That difficult question it leaves to Philosophy, and so far Philosophy has failed to find an answer.

NOTE TO PAGE 18

The schoolboy learns a useful kind of arithmetical shorthand:

For 100 he writes 10×10 , or 10^2 .

For 1000 he writes $10 \times 10 \times 10$, or 10^3 .

For 10,000 he writes $10 \times 10 \times 10 \times 10$, or 10^4 .

For 1,000,000 he writes $10 \times 10 \times 10 \times 10 \times 10 \times 10$, or 10^6 . 10^6 = a million, 10^{12} = a billion, 10^{18} = a trillion, 10^{24} = a quadrillion, and so on. The actual names do not much matter. The little index number is the important thing: it shows *how many* 10's have been multiplied together.

The number of stars actually visible above the horizon on a bright starry night is just about 3000, and if the schoolboy can count as quickly as his watch ticks, i.e. 300 times a minute, he could count the 3000 stars in 10 minutes. To count a million (10^6) at this rate would take him 50 hours (about 2 days and 2 nights). When we proceed much beyond 10^6 , we soon get some surprises, as very easy little sums will show us at once. For instance, to count a billion (10^{12}) would take about 6000 years; to count a trillion (10^{18}) would take 6000 million years. Hence to count the total number of stars in the universe, i.e. ten thousand trillions (10^{22}) would take, if we counted 300 every minute and never stopped, 60 billion years! How easy all this arithmetic is, but how enormously impressive are the results. In making estimates of this kind, we may always neglect exact numbers and work to the nearest 10; then we can work the sums mentally.

CHAPTER IV

Science: its Methods

1. Animals: Their Apparently Methodical Ways.

Watch a bird building a nest. Is the bird methodical? Undoubtedly. Is it working according to a plan? Apparently. Then is it intelligent? Hardly, for it is simply repeating exactly what innumerable generations of its ancestors have done before. Its method never varies. It is customary to say that the bird is acting in accordance with *instinct*, but what is instinct? We do not know, though people who use the term seem to suggest that instinct is something inherited. If so, how did it originate?

Watch a garden spider spinning its web. Take special notice of the way in which it runs out its foundation lines, and how it invariably tests them for tautness. Note the perfect spiral geometry which follows, and the perfect fastening at every junction. The engineering (not an inappropriate term) and the geometry seem to be wonderful, but there is nothing *new* in either; the animal is simply repeating the plan of innumerable ancestors. If it originates nothing, can we rightly say that it is showing intelligence?

Watch the perfect swimming of a duckling as soon as it leaves its shell. It does this even if it is hatched out by an ordinary hen. Clearly there is no teaching. Again, is there any intelligence?

A pig seems to know at once if it is passing over a place where truffles may be found. Can we be sure that its knowledge is due to its specially sensitive power of smell? In such a connexion the word *scent* is often used, and it is a

known fact that a lost dog will find his way back home supposedly because of this particular power. But the route taken may be 80 or 100 miles long, and all traces of scent must have been lost, perhaps in the ceaseless traffic. *How* the dog gets home we simply do not know. Watch a dog at sheep-dog trials. The things he does so successfully seem wonderful, and it is almost impossible to deny him intelligence. But does he depart one iota from what he has already been taught to do during his training? Is there any sign of any sort of rudimentary thinking? It is exceedingly doubtful.

Watch a chimpanzee at the Zoo piling boxes one on the other in order to reach for some fruit placed on a high shelf; or sitting at table, drinking a cup of tea; or putting on some sort of loose coat. How intelligent, we say; how methodical. But does he do one single thing that he has not been trained to do? Is he anything more than an imitator?

Do animals ever use tools? A hungry thrush finds a snail. He cannot pick up a stone and use it as a hammer to break the shell, so he picks up the shell and breaks it on the stone. It almost looks as if he were using a primitive tool, but he is probably doing exactly what generations of his ancestors have done, and nothing more. Does "instinct" explain? No, it *explains* nothing.

It is pretty certain that animals never work according to plan, i.e. a plan which they have *thought out*. So far as their actions are in any sense methodical, they are automatic. Nevertheless, can we wholly deny them some form of rudimentary intelligence? For instance a burnt dog avoids the fire; to that extent at least he seems to put one and one together.

2. Primitive Man.

What about man? A newly-born baby greedily sucks at its mother's breast; it has had no training whatever, and we feel bound to deny that its action shows any sort of intelligence. But watch the child carefully during the next year or two, signs of intelligent action rapidly multiply, though these will differ greatly according to the liberty the child is given

in the nursery. He may develop as a little autocrat, or he may develop as a well-disciplined child, but in either case he gradually learns to plan little things for himself, to adopt *methods* and even to improve upon them. When he gets to school he will certainly meet with opposition, and he will be driven, willy-nilly, to try to counter it. His methods may be very clumsy, but they will at least be methods, and he will willingly learn to improve upon them by watching the methods of others. Any original elements he may introduce into his methods may fail, but they have at least been thought out. His mind has been at work, and therein lies the essential difference between him and animals.

Then there is primitive man. Assuming the truth of evolution, the question of all questions is, when and how did man first show signs of an active *mind*? He probably continued to eat his food raw for hundreds of thousands of years: when did he first cook it? He may have been able to make a fire hundreds of centuries before he used it for cooking, but what made him first *think* of cooking? An accident? Lamb's story of the first roast pig is not without interest, inasmuch as the Chinaman who accidentally burnt down his house and discovered roast pig in the ruins assumed that the burning down of the whole house was an essential part of the process of providing such a dish. This is one of the aspects of true scientific method—*the exact repetition of an experiment, a careful examination of all the circumstances of the experiment, the gradual elimination of all unessentials and the discovery of the essentials*. How did primitive man first discover fire? Perhaps by accident, as the result of a lightning flash. If so, and if the fire went out, he may have had to wait a long time before the same thing happened again. We can imagine the lingering tradition in those far-back days, of the wonderful thing that had wrought such destruction and yet had provided such comforting warmth and had then disappeared. But come again, in some form, it did, and man eventually mastered it, and every stage of the mastery was a step in true scientific method. And so civilization advanced. Man learnt to clothe

himself, to make tools and to use them, to sow seed, and to defend himself by making weapons superior to those of his enemy.

He became more and more anxious to induce nature to help him. Think of his first attempts in any new direction, of his failures, and of his ultimate victory, ever thinking, planning and contriving, and adopting methods which became more and more scientific. He must have invented speech in very early days, and later, writing, though the perfection of either of these arts, beginning with crude sounds and symbols, must have extended over many ages. Much later came the working of metals, the invention of gunpowder, the invention of printing, the invention of the mariner's compass. All down the ages man has sought new knowledge; his curiosity about the world in which he lives can never be satisfied. He may search in his library or in his laboratory, but he is searching for something *new*; he may use a telescope or he may use a microscope; he is merely continuing to do what he did as a small boy before he went to school—asking questions, searching, finding out. All his life long his curiosity is insatiable.

3. The Methods of Scientific Workers.

Every scientific worker engages in exact observation, in the accumulation of facts which admit of no doubt and which can be verified. Emotion plays no part in his work. He wants to get at the *facts*, and so far as his feelings are concerned he is quite indifferent to the results arrived at.

The ancient Egyptians had mastered some of the elementary principles of scientific method 6000 years ago; they had, for instance, constructed a straight sloping shaft within the body of one of their huge pyramids, up which the north polar star was clearly visible. They must therefore have mastered something of surveying, of measuring, and of astronomy. Three or four thousand years later, certain ancient Greeks came into great prominence, the greatest of them being Plato, a mathematician, and his pupil, Aristotle,

a biologist, though both of them took almost all knowledge for their province. Greek science was confined almost exclusively to geometry and astronomy. The little physics they did was not based on experiment, it was nearly all born in their imagination, and rarely if ever verified.

But they were wonderfully accurate observers of the skies, and considering that they had no telescopes they made remarkable progress in astronomy. Hipparchus was their greatest astronomer; it was he who determined the length of the year to within six minutes of its true value, and he who gave a true interpretation of the precession of the equinoxes—a remarkable achievement. But he declined to accept the suggestion of a predecessor, Aristarchus, that the sun was the centre of the solar system and that all the planets, including the earth, revolved round it. He stuck to the old Greek notion that the earth was the headquarters of the universe, and that both the sun and the planets revolved round it. Could we not, he asked, *see* that the earth was motionless, and could we not *see* the other bodies moving in their paths?—so it was argued. And this basic idea was not finally exploded for nearly 2000 years. Even Ptolemy, a famous astronomer who lived when the Romans were invading Britain, adhered to this geocentric hypothesis.

The early astronomers were greatly puzzled by the curious paths which the planets seemed to take. The *general* path of a planet was seen to be circular, but whilst it obviously moved forward for a few months, it then seemed to stop and move backwards for a time, then to stop again and once more move forwards. Closer observation showed that the paths really consisted of a series of flat *loops*. If we assume that the sun, and not the earth, is the centre of the whole system, it is seen at once that our senses have been deceived by the relative motions of the moving bodies. How easily we are similarly deceived when we are travelling in a smoothly running train if another train on a parallel set of rails overtakes us! Relatively to the other train we seem to be moving backwards.

Not until the sixteenth century was the matter finally settled, and then Ptolemy's geocentric system was finally abandoned. By laborious calculations based upon a great number of accurately recorded observations Copernicus convinced himself that the sun is the centre of the orbits of the planets. His arguments were irresistible, and the Copernican heliocentric hypothesis henceforth took the place of Ptolemy's old geocentric hypothesis. Science has since confirmed it in a great number of ways. If we adhere to the old hypothesis that the huge sun moves round the tiny earth every twenty-four hours, we make him travel at the rate of twelve million miles an hour! And we must remember that the sun is a million times the size of the earth.

The Churches had always adhered to the old Greek idea that the earth was the headquarters of the universe, and they were furious when irrefragable proofs were brought forward to the contrary. Again they were angry when Kepler, a German astronomical mathematician, showed that the paths of the planets were not circles but ellipses. The Greeks had pronounced the circle to be the one "perfect" curve, and here was Kepler displacing perfection in favour of such a squat ugly curve as an ellipse: But Kepler did much more; by observation and calculation, he established the exact relation between the distances of the planets and their times of revolution round the sun. There was a simple mathematical law which applied equally to all cases.

Still another scientist offended the Church. This was Galileo, an Italian who was virtually the founder of rigorous scientific method. He was brought before the Inquisition because of a book he had written in defence of the Copernican hypothesis, a book which was quite unanswerable. But that was not his only offence to people in high quarters. For instance, when quite a young professor he made fun of his university colleagues for their adherence to antiquated opinions that admitted of no sort of proof. One of these old opinions had come down from Aristotle—that a ten pound weight fell ten times as quickly as a one-pound weight;

he therefore carried a weight of each kind to the top of the leaning tower of Pisa, dropped them together from the parapet, and they clanged simultaneously on the pavement below. His opponents accused him of playing them a trick: how *could* the weights reach the ground simultaneously? it contradicted Aristotle and therefore was impossible. Galileo invented the telescope and was then able to extend his observations enormously. But his rivals refused even to look through it: how could it possibly reveal things that Aristotle had not seen? Galileo's greatest discovery was his law of falling bodies—bodies fall with a constant acceleration which is the same for all. This is the greatest success of the early days of true scientific method.

An even greater exponent of scientific method was the Englishman Isaac Newton, the greatest mathematician the world has so far known. He was at Cambridge during the reign of Charles II. He was an astronomer and a physicist as well as a mathematician, and when still a very young man his researches led him to ponder over and to compare Galileo's and Kepler's laws.

1. *Galileo's laws of falling bodies*: in a vacuum all bodies fall at the same rate; and at the end of any given time they have a velocity proportional to the time in which they have been falling, and they have then fallen through a distance proportional to the square of that time.

2. *Kepler's laws of planetary motion*: (α) planetary paths round the sun are ellipses, the sun being at one of the foci; (β) a line from the centre of the sun to the centre of the planet sweeps over equal areas of the ellipse in equal times; (γ) the square of the time of revolution of each planet, divided by the cube of the mean distance from the sun always gives the same numerical result.

Newton performed the amazing feat of fusing all these laws into a single new law—his famous Law of Gravitation: the attracting force between any two bodies is inversely pro-

portional to the square of their distance apart, and directly proportional to the product of their masses. The first heavenly body on which Newton put his law to the test was the moon. Unfortunately, owing to the incorrectness of the value that he used for the radius of the earth, the result did not come out right. Like a true man of science Newton concluded that his Law, and not his observations, must be wrong. When, however, a few years later the earth itself was more correctly measured, it was found that the law *did* correctly apply to the observed motion of the moon. This was a tremendous triumph for scientific method—the fusion of related facts which had been separately and accurately observed, in this case, positions, distances, directions, and times. Finally, Newton succeeded in proving by rigorous mathematics that the whole of Kepler's laws were direct consequences of his Law of Gravitation—one of the finest achievements in the whole history of science.

A century later, John Dalton, a Manchester mathematical master, who was interested in quantitative chemistry, discovered that when elements combined together to form compound substances, they always did so in invariable proportions by weight. No matter how much or how little of a substance was used, the same number always seemed to emerge with every particular element, e.g. 1 with hydrogen, 12 with carbon, 14 with nitrogen, 16 with oxygen, 32 with sulphur, 56 with iron, and so on. Readers who did a little chemistry at school will remember how difficult it was to induce their balance to weigh with anything like accuracy, yet here was Dalton, weighing with such accuracy that the basic quantitative law of chemistry seemed almost to strike him in the face. He must have engaged in thousands of the most careful weighings, or he certainly would not have made his wonderful discovery. The explanation which he suggested we shall come to presently.

Another famous British master of scientific method was Michael Faraday, a London newspaper boy who became Davy's assistant at, and later the chief of, the Royal Institu-

tion. He knew nothing about mathematics, save arithmetic, and yet he became the most famous physicist the world has ever known. His resourcefulness in experimental work was amazing. Hardly anything of electricity and magnetism was known when he began his researches, yet in the course of a very few years he discovered that they were twin forces—that *moving electricity* (i.e. an electric current) had a magnetic effect, and that *moving magnetism* had an electric effect. In short, Faraday taught us how astonishingly simple it is to make electricity, *merely by moving magnetism*. Get the engineer of some great generating station to show you round. The running machines are bound to impress you, but most of these are engineers' devices for producing great power and great speed. Basically, they all reduce to a system of *magnets* and *coils*. The interesting feature of such a station is that, in spite of the extraordinary developments in electrical engineering in recent years, Faraday's original magnet and coil, which he made with his own hands in 1831, are still basic and fundamental. But Faraday himself was much less interested in possible technical developments than in pure science. Money-making did not interest him at all, and he and his wife were content with his small salary and their small flat at the top of the Royal Institution. Illness enforced his retirement at the age of seventy, when he went to live near Hampton Court, in a house given him by Queen Victoria.

Charles Darwin when at Cambridge attracted little attention. Finding that biology was not taught, he rarely attended lectures and took only a Pass degree. He was, however, anything but idle: amongst his fellow-students he was known as "the bug and butterfly hunter", for he spent his time in studying the plants and animals of the district, in their natural surroundings. Then he travelled widely and continued the same work in different parts of the world. He amassed an enormous number of facts and classified them, and he had a wonderful gift for seeing differences and seeing resemblances where other people could see none, and eventually he was driven to the irresistible conclusion that all

animals, from the very lowest forms to man the highest, constituted but one vast family having a common origin. They did not form a single *line*, for there had been very frequent branchings, but they did constitute a perfect genealogical *tree*. In the course of ages many branches of this tree had been lost, and therefore the complete tree could not be reconstituted, but those that survived, mostly in the form of hard parts—the bones, fossils, and shells of our museums—fitted into the scheme exactly. Sometimes these remains show a particular ancestral line completely a long way back, for instance, that of horses. And an enormous amount of confirmatory evidence, geological and palæontological, has been brought forward since Darwin's time. There is still one outstanding difficulty—that of the true relation between different groups of animals—species, genera, and so on. We understand how different *varieties* (e.g. of dogs) have been brought about, but we do not yet know how, for instance, cats, dogs, horses, cattle and sheep came to exist as five quite distinct groups. How did these particular divergencies take place in the ancestral line? We do not yet know, though we are fairly certain of the origin, from a common ancestral stock, of the much greater groups, reptiles, fish, birds, and mammals. So many new facts are, however, coming to hand that no well-informed person could any longer think of ascribing the existence of separate species to different acts of special “creation”. Research in genetics is rapidly breaking down the difficulty.

4. The Science Worker in his Laboratory.

The Third or Fourth Form boy in the Physical or Chemical laboratory at school is there to have “a good time”. In the Fifth he is more serious, for an examination looms ahead. In the Sixth he is more serious still, for in these days scholarships are hard to get. At the University, serious work is essential, or that coveted “class” may be lost. Post-graduate work, if undertaken at all, is a hard grind; it is almost certain

to be research work, and unsuccessful research workers are quickly frowned upon.

Probably no work is harder, perhaps none is so hard, as research in science. Certainly no work is sterner or demands such intense application. Constant disappointments are inevitable, but when success comes the reward is rich. By this is not meant monetary reward but the reward of discovering something *new*, some new fact hitherto entirely unknown. The work to be done is usually by no means exclusively mental; more often than not it demands manual skill of a high order, and great resourcefulness.

The reader is not likely to be welcomed in a busy research laboratory unless he has a friend there, but, if he has the opportunity, a visit will teach him much, whether the work in progress is some branch of chemistry or of physics or of biology, or of engineering, or what not. Research laboratories, large or small, may exist by the score in a modern university, and there is a great variety in other places, e.g. those associated with drugs, medicine, bacteriology, agriculture, and so on almost indefinitely. Everywhere it is the same, work carried on with an intensity of application and often in a silence that is almost uncanny. Watch A with the high-power microscope; what is he hunting for? Watch B with his sensitive balance; why is he weighing to such a minute fraction of a gram? Watch C about to switch on that incredibly high voltage current: does he scent no danger? Watch D as he works out the arithmetic of his last batch of experimental results: will it harmonize with the "law" which he adopted provisionally for the purpose of linking together previous results? watch D's anxious face and then look out for his smile or for his look of disappointment. Spend a midnight hour with E in his observatory and do a little star-gazing: watch the stars rushing across the field of vision of his equatorial, and get one of the surprises of your life: ask E to tell you the story of the discovery of Neptune and how the planet came to be hunted for.

Researchers still work alone occasionally. A former col-

league of mine, who had distinguished himself in many ways as a young man and had been on the staff of the Imperial College for some years, decided to follow up a particular line of research that might eventually lead to his election to the Royal Society. His special subjects were chemistry and mineralogy. A necessary piece of apparatus for his research was an extremely sensitive (and very costly) chemical balance, and he was lucky enough to find at Oxford, where he lived, an old house with very solid foundations. He rigged up the cellar as a laboratory and his balance was fixed on a heavy stone slab in such a way that it was virtually vibrationless, despite the not very distant traffic. He managed to finish off his weekly professional work by Friday afternoon, and then went straight away to his laboratory, where he stayed until Monday morning. He slept, so far as he slept at all, on a convenient "shake-down", but an alarm clock often called him up, inasmuch as some of his experiments, which proceeded all night long, required periodical inspection. One night I spent a couple of hours with him, but his normally friendly self had become quite changed. I had never seen a man so concentrated on his work and he simply could not tolerate the slightest interruption. I could see I was an interloper, and I stole silently away. Some six years later his research was pronounced to be "brilliant", and he was given the coveted Fellowship. Was that distinction dearly bought? His work had not the slightest bearing on industrial processes, on human welfare, on war. It was all "pure science"—a slight lifting of the veil that had hidden away some of nature's secrets.

A complete research may demand the attention of experts trained in different departments of science. Consider, for instance, the secrets of an ordinary hen's egg. If the egg be broken open, all that the ordinary observer is likely to see are the white, the yolk, and the two yolk-anchors (chalazae). The nutrition expert will ask himself, why does the egg form such a perfect and practically all-sufficing food? He analyses both the white and the yolk and finds that each is

rich in special proteids and in vitamins. The embryologist will take an egg from the incubator every few hours for three weeks, and note the complete development of the chick from the almost invisible zygote (the fused parental cells) to the fully-formed bird. The chemist will be specially interested in the egg as a sealed box: how does the living growing embryo-chick save itself from being poisoned by its own by-products? The chemist discovers that these products are not given out as active poisons but are deposited as inactive crystals, the egg-interior thus being kept perfectly fresh for the three weeks. Bio-chemistry has itself become a very big subject, as indeed has almost every other subject of science.

5. The Researcher as a Thinker.

A scientific Law or Principle embodies a particular group of facts which, under certain conditions have been established by observation and experiment and have been recorded. The construction of the Law is brought about by the synthetic activity of the mind, which uses the perceived facts as its raw material. From the perceived facts a selection is made, the others being ignored as irrelevant, and this selection process is really a process of abstraction. The degree of abstraction employed indicates the degree to which the constructions of the mind (the concepts) are derived from, and are based upon, the perceived facts of the senses (the percepts). The sense of sight, and in some measure the senses of hearing, feeling, taste, and smell, provide the percepts; these are taken in by the mind and manipulated, fusion is effected, concepts are formed, and laws or principles are gradually evolved. A scientific law is accordingly always abstract in the sense that it represents only a part of what in any individual case is actually perceived.

A group of laws or principles considered as forming a single body of doctrine is known as a scientific *theory*.

A main function of a scientific theory or conceptual scheme is to provide an ideal co-ordinated representation of some particular selected range of physical phenomena. But

there is a second and much wider function of such a scheme: it is intended to predict what will be observed in new circumstances which, though allied to those already known, differ in some degree or in some characteristics. The value of the scheme lies in its power of prediction.

Clearly any theory must be regarded as hypothetical and provisional, never as dogmatic and final. It must stand or fall by its predictive success of consequences which are in harmony with perceptual facts.

But sometimes men of science use the term *theory* when really they mean *hypothesis*—in fact the usage of the two terms is less strict than it should be. A *theory* usually applies to a whole body of doctrine, provisionally established and accepted. The theory may include numerous laws and hypotheses; the laws may be quite sound, may in fact be little more than a sort of shorthand registration of a unified group of facts; the hypotheses are never free from doubt. The process of tracing any regularity in any complex set of appearances is necessarily tentative; we begin by making some supposition to see what consequences will follow from it, and by observing how these differ from the real phenomenon we learn what corrections to make in our assumption. Our first provisional hypothesis is thus corrected, and the consequences deducible from the corrected hypothesis are again compared with the observed facts; this may suggest still further correction, and so we go on until at last the deduced results actually tally with the phenomenon observed.

In any hypothesis we assume a sort of secret inner organization of real things and processes; success depends upon experience, inventiveness, and resource. But it should never be forgotten that an hypothesis is nothing more than a *mentally constructed and quite imaginary* mechanism, accounting for the facts. We must be under no delusion that our pictorial conception is representative of the actual machinery of nature.

The atomic theory, really little more than a simple hypothesis as formulated by Dalton, gradually extended its field

as new discoveries were made. In quite early days it was made to include not only Gay-Lussac's *Law* of gas-volume combination, but also Avogadro's *Hypothesis* that, under the same conditions of temperature and pressure, equal volumes of all gases contain the same number of molecules. The law and the hypothesis as parts of the general atomic theory still hold, but the theory as a whole has now become extremely complex because of the astonishing discoveries of recent years.

Dalton assumed that every elementary substance consists of *atoms*, all atoms of any one substance being alike but differing in some fundamental way from the atoms of all other substances. Each atom was assumed to be a tiny solid sphere, absolutely indivisible, far below the range of vision. Its great characteristic was its specific *weight*. For any atom this weight was unique, no two elementary substances having atoms of the same weight. And this particular assumption involved in Dalton's hypothesis has turned out to be true: we now know 92 elements and we can arrange them in numerical order from 1 to 92 according to their weight. But that part of Dalton's hypothesis which assumed that atoms were indivisible little spheres of specific substances has turned out to be completely wrong. We now know that all atoms are compound, and are made up of precisely the same ultimate particles, which by nature are electrical. The difference between, say, gold and iron, is essentially a *numerical* difference in these ultimate particles.

The reader need not reject Dalton's hypothesis on the ground that hard solid spherical atoms are inconceivable as constituents of a gas; the tiniest speck of dust seen in a sunbeam must contain many millions of atoms, which therefore cannot possibly be visualized, though they may be conceived. But any chemist who *describes* an atom, or biologist who *describes* a gene, is allowing his imagination to run riot. At present we know so little about atoms and genes that any attempt to construct one on a scale large enough to be seen and examined is like an attempt to reconstruct an antediluvian

man from a hair and a fragment of finger-nail discovered in an Assyrian tomb. We must beware of pictorial visualizations built up from stray fragments of knowledge.

It is always extremely unlikely that any hypothesis will ever prove to correspond to objective reality. The first really comprehensive hypothesis ever formulated was Newton's Law of Gravitation (Newton called it a Law partly because of its simplicity, partly because he disliked the term hypothesis). Using this Law, astronomers were able, for 200 years, to predict the exact positions and the times of happening of events in the solar system, and the predictions were nearly always correct. Not quite always: there were occasional small discrepancies. What was the cause of them? New observations made with greatly improved instruments showed that Newton's Law had been deduced from observations which were not quite accurate, and some twenty-five years ago Einstein formulated a new law, much more complicated than Newton's (and therefore at first not very popular), but predicting events with marvellous accuracy. Einstein abolished space and time and gravitational force, and for these he substituted "space-time", and theoretical mechanics became a species of geometry.

It is hopeless for the reader untrained in science to understand recent developments in theoretical physics. The theory of Relativity and the Quantum hypothesis are bound to be altogether beyond him. That does not matter, inasmuch as most of the underlying experimental work, and its *general* significance, may readily be understood by all intelligent persons, and simply written books are readily available.

In an address at the American Scientific Congress at Washington, 15th May, 1940, Professor Einstein said: "There was always an attempt to find a unifying theoretical basis for all the single sciences, consisting of a minimum of concepts and relationships, from which all the concepts and relationships of the single disciplines might be derived by logical process. This is what we mean by the search for a

foundation of the whole of physics." And after pointing out that Newton's theory of gravitation and its action at a distance had long been considered artificial, he went on: "The development through the present century is characterized by two theoretical systems essentially independent of each other: the theory of relativity and the quantum theory. The two systems do not directly contradict each other, but they seem little adapted to fusion into one unified theory. . . . For the time being, we have to admit that we do not possess any general theoretical basis for physics. . . . I cannot believe that we must abandon, actually and for ever, the idea of direct representation of physical reality in space and time, or that we must accept the view that events in nature are analogous to a game of chance. . . . Every man may draw comfort from Lessing's fine saying, that the search for truth is more precious than its possession."

The reader is always likely to be caught out when he makes use of those abstract scientific terms which he thinks he understands clearly. Consider the term *motion*, for instance. We see a body *moving*, we ignore its dimensions and its nature, and we abstract just its *motion*, and nothing else. Now can we conceive of that motion *alone*? What *is* it? Imagine the physical body itself to be annihilated: what has become of the motion which we abstracted from it? We simply cannot think of motion if there is no moving body. Again we speak of the *force* of gravitation, and vaguely we think of the sun "attracting" the earth, and the earth "attracting" a stone. All that we *know* is an accelerating movement, but why there is such a movement we have no idea at all. Again, consider the term *mind*. Is it abstract or concrete? It is very hard to say, different people use the term in such different senses. But change it to the term *soul*, and at once we all agree that we are using a concrete term. Or change it in the reverse direction and call it *consciousness*, and at once we all agree that we are using an abstract term.

The theories of modern science have taken on an extremely abstract form, and are necessarily quite beyond the

range of the non-expert. It must, however, be admitted that only those who understand them can have a grasp of the structure of the world as a whole. It has been said that the power of using abstraction is the very essence of intellect. So it is, but abstractions as used by ordinary people are the source of most of their ambiguities and muddle-headedness.

In some quarters the feeling prevails that men of science arrogate to themselves a dogmatic infallibility. That feeling is not justified. They are honest in their claims that certain facts are proved; they are equally honest in their admission that all their hypotheses and theories are provisional and are always open to revision in the light of new facts. No doubt they sometimes use their own abstract terms a little vaguely, and sometimes make forecasts that are a little wild, and then they undoubtedly do tend to lessen our confidence in them. That within their own province scientific methods are perfectly sound cannot be denied. *But those methods are quite useless in any exploration of human actions or human motives*, except in their primary demand for bed-rock facts.

The misuse of abstract terms is half the trouble in all our intellectual explorations, humanistic or other. Ask any half dozen intelligent friends to write down definitions of the common terms, *truth, goodness, beauty*. The differences will be amazing, and the ingenuous nature of some of the answers will probably be laughable. Truth may gravely be centred round some form of childish fib-telling; goodness may be given an authoritarian setting or may be extracted from the every-day experience of a personal environment; beauty may be thought of subjectively or objectively. There will be no agreement about the true essence of any one of them. And here scientific method can give no help.

CHAPTER V

Science: How far Responsible for War

1. War in History.

It is a remarkable fact that, according to the records in the earlier Books of the Old Testament, God should have been looked upon by the Hebrews as a *vindictive* God. Such primitive people, naturally afraid of another Deluge that would again destroy their little world, decided to build a tower that would "reach unto heaven". This was supposed to have made God angry, and to punish them he "confounded" their language, so that they could "not understand one another's speech". This might be supposed to explain the origin of eventually different nations, their misunderstandings, their rivalry, their wars.

When we were children and were made to learn the ten Mosaic commandments, we said, "I the Lord thy God am a *jealous* God, visiting the iniquities of the fathers upon the children unto the third and fourth generation." Thus we took in, almost with our mother's milk, this notion of what constitutes divine justice, and naturally we assumed that it is right to mete out the same kind of justice to our enemies "unto the third and fourth generation".

Again and again in the Old Testament we read of ruthless murder and destruction, and the claim is almost always made that it was fully justified and done "in the name of the Lord". We may quote the reference to the city of Jericho: "and they utterly destroyed all that was in the city, both man and woman, young and old, with the edge of the sword; and they burnt the city with fire."

Thus war, vindictive war, which forms such a prominent feature in these old Bible stories that children love so much, was from the earliest times taught and defended as an inevitable part of national life. Primitive man's earliest fights were doubtless made on behalf of his family, then on behalf of his clan, later on behalf of the larger tribe, then on behalf of the nation. At every stage ruthless victory was followed by the absorption, partial or entire, of the beaten foe.

Until quite recent times, war-stories as told by historians were often made so interesting, and the winning side was commonly so highly eulogized, that boys came to look upon the world's master bullies as great heroes; in fact, their eyes still glisten when they read of Alexander "the Great", and William "the Conqueror". And yet in the whole course of history has there ever been anything worse than the wantonly brutal wholesale butchery meted out to the people between Humber and Tyne by that same conqueror?

As for weapons it has naturally always been the practice of warriors to use the most efficient they could find: only that way was victory probable. When primitive sticks and stones were eventually replaced by cutting implements, real butchery began. At first, cutting and stabbing were effected by implements of flint, then came bronze, and then the much harder iron and steel. From Greek and Roman times right down to the Middle Ages, the sword and the battle-axe always played a leading part, some sort of shield being used in defence, and sometimes body-armour. During the wars of the Roses, the powerful knights on horseback, man and horse alike being armoured, with their huge battle-axes hewed lanes through the masses of foot-soldiery, and totally ignored the arrows shot at them. A little earlier (in 1346) gunpowder was first used in battle; it is, of course, a mere mixture of three common ingredients, and it was centuries before chemists succeeded in making the far more deadly explosive compounds now in such common use. All down the ages warriors have constantly sought new and more effective weapons with which to butcher the other side.

To such an ever urgent call, ambitious men have often responded. One of the greatest intellectual giants of all ages, the Italian Leonardo—he was artist, sculptor, man of science, engineer, everything, and in everything he easily excelled all his contemporaries—placed his inventive military resourcefulness at the disposal of the Duke of Milan. A little later, another genius, Galileo, who had become professor of military science at the University of Pavia, willingly sold to the naval authorities the telescope which he had invented, because of its obvious usefulness to them. In short, a close connexion sprang up between war and developing science, and in the eighteenth century the French schools of gunnery were the only places where science was systematically taught. Later on, the large-scale smelting of iron, and the introduction of the steam-engine, were directly due to the ever-increasing need of gunnery in warfare. And let it be noted that science was then rarely more than a responsive handmaid to the ever clamant demands of war, and it occasionally happened that men of science looked forward with much apprehension to war developments of the future. Our own Joule, for instance, said that he knew there were those who thought that the improved war instruments of destruction would tend to put an end to war. But “I cannot think that such an opinion is based on common sense; I believe that war will not only be more destructive but will be carried on with greater ferocity.” This was said nearly a century ago, and how truly prophetic his words seem to have been.

It is, however, very doubtful if the individual modern soldier is more ferocious or if he takes a greater delight in fantastic acts of butchery or torture, than the soldier of 2000 or 3000 years ago. The horrors of a bestrewn battlefield have probably been always much the same. I remember how, in the days of the old volunteers of fifty years ago, it fell to my lot to train the men of my company how to use their bayonets, viz. by thrusting the weapons a few inches into loosely suspended bags of straw, giving them a twist, and then instantly withdrawing them; and the old Martini-Henry rifle bullets

were as big as one's little finger. In either case the actual wounds would have been pretty ghastly. The dreadful carnage of the present day does not seem to be due so much to particular wounds, though these may be beyond all telling, as to multiple wounds due to rapidity of machine action. The horrors of poison gas are closely associated with choking and burning pains in the throat and chest, of a particularly extreme kind. But it is quite unnecessary to enlarge on these horrors. The main question here is, *to what extent is science to be blamed for them?* And this question leads to the greater question, *What are the causes of war?*

2. The Causes of War.

The old-fashioned school history books devoted much space to the details of the wars which had occurred down the centuries, and in the case of every war there was an almost stereotyped paragraph devoted to the "causes" of that war. These causes were usually the *immediate* causes of the war, and may be summarized under such headings as religious fanaticism, the thirst for power and glory, the ambitions of unscrupulous men, the jealousy of neighbouring states, the search for raw materials, and so forth. But, speaking generally, such immediate causes ought to be traced back to causes of a more ultimate character.

In the winter of 1939-40, a series of eight addresses* were delivered in London under the auspices of the British Institute of Philosophy. The eight speakers were men well known for their independent judgment and they were eminent in different departments of human thought. Each did his best to probe to the bottom of the root-causes of the war then raging, and all the addresses are well worth reading and pondering over. We give short quotations from each.

1. Professor W. G. S. Adams, Warden of All Souls College, Oxford.—"Why is it that we are distrusted? Have we carried out our obligations and our trusteeship as we should

* Since published under the title, *The Deeper Causes of the War*.

have done? Have we tried to understand the mentality of those who have not felt and thought as we have? Have we been fair in our appreciation of their difficulties and their achievements? Have we discriminated and recognized what was positive and good in the systems which other countries have developed? Have we tried to weigh dispassionately their grievances? In trying to search out so deep-rooted a question as the causes of war, let us see that our judgment is kept clear by patient, honest, fearless, self-criticism. The decline of moral and spiritual values is the deepest of all the causes. We are in an age of great materialism, good and bad. The spectacular achievements of science, the critical analysis of traditions and beliefs, the perplexity of the issues and events of life, all tend to an unrest and thus to an apathy in moral and spiritual values."

2. Professor Gilbert Murray, formerly Regius Professor of Greek in the University of Oxford.—"I need not dwell on the glorification of war and the horrible misleading of the young which constitutes Nazi education. More significant still, perhaps, are the doctrines preached by Nazi intellectuals, pouring scorn not only on normal Christian morals but on the sanctity of truth itself. The Professor of Philosophy at Heidelberg declared, 'We do not know of or recognize truth for truth's sake, or science for science's sake. History is not to be true history but German history. The reverence for moral right is a thing that belongs to bygone times.' 'The only good peace,' writes Herr Hitler, 'is a peace established by the victorious sword of a master nation.' Why was an undistinguished, raucous, verbose, mendacious, and half insane Austrian mystic accepted as the adored leader of a great nation? The answer is clear enough. He represented with paranoiac intensity the prevailing emotion of a proud and warlike people, maddened by defeat."

"We (British people) are quite stupid in our insensitivity to danger. Consequently we are free from all those evil lessons that terror teaches, lessons of hate, of suspicion,

of violence, of intolerance. No doubt the anxieties of recent years have had their effect upon us, but still we are on the whole a singularly good-natured, tolerant people, moderate in our political controversies, and eager to shake hands with old opponents after a fight. Think of the great popular welcomes given to the Boer generals and to Gandhi, the wide popularity given to Hindenberg."

"There is the possible war of colours; how long will the yellow or the brown races tolerate the supremacy of the white? How long will even the black millions of Africa remain contentedly at times half-enslaved, and at times grossly ill-treated? There is the clash of civilizations—Christian, Moslem, and Oriental. How long will the overcrowded nations like Japan, China, and India contentedly remain choked with surplus population, while the owners of the vast empty territories all round the Pacific deny—and for very weighty reasons deny—their people the right of entry?"

"Communism as an economic system may be quite as satisfactory as most other systems, but if it involves a bloody class-war and can be kept in being only by the ghastly weapon which Lenin called 'mass-terror', we can be sure that no mere change of social organization is worth the price. Class-war I regard as Public Enemy Number Two, but Number One is still that permanent military ambition which has imposed upon Europe five aggressive wars in the limit of a life-time."

3. The Right Hon. Viscount Samuel, President of the British Institute of Philosophy.

"Has a state duties to its own peoples, and none to other peoples?"

"Is any action legitimate which will promote the immediate interest of the particular state?"

"Ought war to be maintained as an institution on account of the virtues it invokes and other virtues it brings?"

"Are the principles of Race and Soil a right basis for a nation's policy?"

"Should the control of a country's affairs be entrusted to an individual, and loyalty to him be identified with patriotism?"

"Does the citizen exist for the sake of the state, and not the state for the sake of the citizen?"

"Should the state direct all forms of education and information in order to promote its own ideas, and suppress all other ideas; and this with little regard to truth or falsity?"

"Is the Christian ethic to be rejected, ruthlessness praised as a virtue, justice and compassion condemned as weakness?"

"Does the civilization of the modern world deny social justice to a large proportion of the population?"

"Ought the improvement of industrial conditions, and of environment in general, together with the ultimate disappearance of class distinctions, to be a chief aim of social effort?"

4. The Very Rev. W. R. Matthews, Dean of St. Paul's.—
"I would speak with respect of democracy, which is probably the best form of political organization, but whether a democracy is good or bad depends upon the demos. It is easy enough to imagine a democracy which would be, from the point of view of an intelligent minority, an appalling tyranny. Freedom is the name of the thing which is really worth fighting for, freedom of thought, freedom of speech, and freedom of the person to develop and express his potentialities."

"Two of the most philosophical writers of Nazi Germany have insisted that the Nazi movement is a revolt against the foundation assumptions of civilization as it has existed in Europe, a demand for a new scale of values, a new conception of what constitutes the good life of man. Regarded in this deeper way, the contrast between the Nazi and the Bolshevik revolutions appears to be almost negligible compared with their real affinity. Both are conscious breaks with the past, both repudiate the values which have been the inspiration of the existing civilization, both contain a new

concept of the good for man. Both of them are, in short, spiritual revolutions, and the final proof of this is their ability to inspire in their adherents a religious type of enthusiasm and fanaticism. The convinced Nazi or Bolshevik is exactly like the Christian fundamentalist—with the important exception that he lacks all charity."

5. Sir Richard Livingstone, President of Corpus Christi College, Oxford.—"The vital force of our civilization comes from two sources, from Palestine and from Greece. We may not believe in Christianity, but it is the main source in the spiritual life of Europe. The influence of Hellenism, especially in this country, is important, but it touches a small class. The mass of the people drew and still draw the best part of their beliefs and standards in life and conduct from Christianity, however confused and diluted in the channels through which they pass. To attack Christianity was ultimately to attack the spiritual life of Europe. But this elementary truth never occurred to those idealistic and well-intentioned nineteenth-century Liberals who cleared the ground for Hitler, Stalin, and Mussolini.

"We may condemn Lenin, Hitler, and Mussolini, but let us do them the justice to admit that they are the only great builders of the post-war age. They divined the greatest need and gave their countries a philosophy as a religion, to replace a philosophy and religion which were dead or dying or forgotten. But it is not the old religion of Europe. In Germany and in Italy it has incorporated elements from it, and for the time in both countries, and especially in Italy, the old religion and the new live uneasily side by side. In the end, one will kill the other. The new gospel does not belong to the Graeco-Christian tradition, but is a recrudescence of the barbarism which Christianity and Greece did so much to tame.

"Recent events in Europe come from a break-up of the spiritual tradition. They are an attempt to fill the void, and illustrate admirably the truth of that immensely profound sentence in Pascal: *L'esprit croit naturellement et la volonté*

aime naturellement; de sorte que, faute de vrais objets, il faut qu'ils s'attachent aux faux."

6. Sir Richard Gregory, Bart., F.R.S., formerly Editor of *Nature*.—"The recognition that knowledge of the physical universe is only the bud of a flower which can never be seen in its perfection is the salvation of science. Nature acknowledges no exclusive claims to truth or right of dictatorship in her name, either to this generation or the next. The scientific man has to work for Truth as far as her ways can be comprehended by him, but he is never more than a trustee for posterity, and has no authority to define the functions or limit the freedom of those who follow him. When men believe that complete truth has been revealed to them, they restrain inquiry and persecute those who fail to see the same light. This position can never be taken in science, which invites investigation, welcomes criticism, and rejoices at new truths to supersede or supplement the old."

7. Professor Ernest Barker, Professor of Political Science in the University of Cambridge.—"We are confronted to-day by an unsystematic system of state and political boundaries which is the result of historical contingency, and almost, it may be said, of accident. . . . Germany stands pre-eminent in this general question of boundaries and this general problem of the area of life which is proper to a community. We may say that the historical process has been harsh to Germany and that it has done less than justice, in its assignation of areas, to the powers and capacities of the German people. . . . Germany is the great central nation of Europe, looking East and West and North and South. She has become the great military nation of Europe. . . . From the days of Goethe and Lessing and Kant she has been able to claim that she is the intellectual nation. . . . But Germany does not stand alone. There is the general problem of Eastern Europe and all its detritus. There is the general problem of Balkan boundaries. From the Gulf of Bothnia to the Black Sea and the Ægean there are scattered debatable areas. Here

is the meeting-ground of Teuton and Slav, of Magyar and Rouman.

“There are perhaps three answers which may be given to this problem of area and life-space, three main ways in which an attempt may be made to reshape the results of the historical process. The first—the simplest and also the crudest—is the answer which is given by Germany. She proposes to make a new order of Europe, unilaterally and by herself. She proposes to do so on two bases—*Raum* and *Rasse*. On the ground of *Lebensraum* she would clear for herself an area sufficient for her economic needs and adequate to the satisfaction of a growing sense of prestige. . . . A second answer, which is at the antipodes of the German answer, suggests a joint and agreed solution of the problem of boundaries and areas, by which each community would secure an internationally determined life-span. The third answer is in no way contradictory to the second—it is generally called federalism. European federalism is a thing of very great difficulty, but it has the merit of going to the root of the problem of areas and boundaries and of providing a solution which may well prove to be permanent.”

8. Sir William Beveridge, Master of University College, Oxford.—“The people of Britain and France are as pacific as those of the United States of America. But none of these nations appreciates the reason for their love of peace, as it appears to others; all three nations cause natural irritation by assuming that their love of peace is due to their superior morality. To others it has a simpler explanation. In the general philosophy of dictators, small nations are peaceable because they are afraid, and large nations are peaceable (if they are peaceable) only because there is nothing more for them to get by war. The great democracies as seen by the dictators of Germany and Italy and pictured to the German and Italian people, are peaceful as the rich are conservative, because they are satisfied; they control territories ample for their populations and rich in raw materials. Britain, in

particular, according to a frequent gibe of Herr Hitler, has become virtuous only after two hundred years of successful wickedness. German propaganda in the present war is marked by alignment of attack upon Britain as both imperialist and plutocratic; Nazi socialism carries the banner of the disinherited nations and classes. The picture is grotesque but informing. In the view of their rulers, Germany and Italy coming to unity and power after other nations have carved the world to their satisfaction, cannot be expected to show the same attitude or to be blind devotees of peace. Germany and Italy are 'dissatisfied' powers, needing for their people territories and opportunities now held by others."

Naturally such short extracts as we have quoted fail to do the eight lecturers justice, and every address should certainly be read in its entirety. But the extracts will serve to show that the causes of war are primarily traceable to human motives, amongst which envy, jealousy, hatred, malice, and uncharitableness rank first. Science is called in to help. The would-be conqueror says to science, what can you do to ensure our victory? Can you improve our guns, our explosives, our speed of movement? Can you invent new means of quick and wholesale destruction? Can you help us to make the defenders afraid? If you can do these things successfully, we will certainly make it worth your while. Never mind humanity, never mind morality. Help us to *win*, and your rewards shall be rich.

And the nation to be attacked? What can it do but appeal likewise to science?

Consider the great wars of history. In every case, who was the *man*, and what means did he adopt to stir up the emotions of the people and to keep these emotions at boiling-point?

CHAPTER VI

Science and Civilization

1. Civilization.

The present and former Deans of St. Paul's have given us good provisional descriptive definitions of the term civilization, a term admittedly of very varying connotation and by no means free from ambiguity.

Dean Matthews says: "I hold every civilization to be, in its essence, a distinct phase or movement of the human spirit. No one would question the important influence of geographical position, the state of technical skill and knowledge, the economic conditions, but these are not the essential things. What gives the character to a civilization is the complex of ideas which it expresses. What values did the man of that period seek to realize?"

When "we assert that we are fighting to defend civilization, we mean that we are defending civilization as we understand it and as we have inherited it."

Dr. Inge says: "What we call civilization or culture is a brief episode in the life of our race. For tens of thousands of years the changes in human habits must have been slight, and chiefly those which were forced upon our ancestors by changes of climate. Then in certain districts man began to wish to live beyond his income; this was the beginning of the vast series of inventions which have made our life so complex.

"If we turn to history we find that civilization is a disease which is almost invariably fatal, unless its course is checked in time. The Hindus and Chinese, after advancing to a certain point, were content to mark time; and they survive. But the Greeks and Romans are gone; and aristocracies everywhere

die out. If so-called civilized nations show any protracted vitality, it is because they are only civilized at the top. Ancient civilizations were destroyed by imported barbarians; we breed our own."

If we examine a photograph of a reconstructed head of man as he existed half a million years ago, we are driven to the conclusion that such a man was still at the very dawn of civilization. His physical make-up shows that he had but half-emerged from a lower stock. But if we examine one of, say, Cro-magnon man of 100,000 years ago, we do not hesitate for a moment to place him in parallel with civilized man of the present day. Cro-magnon man may have spent tens of thousands of years in a very primitive environment, without science, without philosophy, without literature. But who can doubt his great natural intelligence? and if he was a "barbarian", was he a greater barbarian than his twentieth-century descendants? Was he more cruel? Was he more vindictive? Was he less human? Was he less kind? In short, was he less civilized?

History seems to tell us pretty clearly that all the great civilized peoples of the past have shown first an advance and then a decline, though not one of those civilizations has lasted more than about 2000 years. And there have been certain peoples which apparently were capable, of their own initiative, of a certain measure of civilization and no more. Others seemed incapable either of creating a civilization of their own, or of preserving unaided, a civilization imposed on them from without. The Kaffirs and Negroes were undisturbed for centuries but failed to move forward.

We use the term *man* in two senses, for the individual man who must eventually die, and for the undying humanity in general of which the individual man is a temporary unit. And similarly we must distinguish carefully between the concrete and the more abstract uses of the term civilization. "A civilization" often refers to a particular people at a certain period of history, a civilization which as a great world landmark has simply disappeared. But although the dis-

tinctive civilization may have disappeared, it does not at all follow that the present descendants of that ancient people are not now civilized; they are probably now members of a larger, looser, less special type of "civilization", perhaps more world-wide. In either of its senses, civilization has always tended to impair valuable human qualities, and in no civilization have these qualities ever seemed to have been more than a veneer, and with the passing away of a civilization the veneer has often worn very thin, though the absorption of a weak civilization into a stronger may have led to a renewed striving and to a refructification of the impaired qualities.

We ought to distinguish carefully between civilization and culture. Civilized society is not a simple cultural unit within which its members possess territorial rights, but is composed of a number of territorial units, each asserting its own culture. There is no greater curse in the world to-day than nationalism with its own culture and its own language, hemmed in within its own ring fence, arrogant and defiant towards its neighbours.

Who can doubt that European civilization (Russian perhaps excluded) is now on the decline? The canker of decay has eaten into it too deeply for the present desperate efforts of some of its sections to have more than a temporary success. European nations have settled down to lives of ease and comfort, they are becoming more and more intellectually lethargic, too fond of lotus-eating. Our present enemies despise us because we are a nation of idlers, and we despise them—for other reasons. But we are all approaching the 2000-year limit.—What limit is that?

Professor Flinders Petrie advances a theory which claims to explain both the rise and the fall of a periodic 2000-year civilization curve.* He supposes that every cycle is initiated by a biological blending of the races; that this gives to the blended stock a new energy which carries it up the civilization scale; that after about 2000 years this effect is exhausted,

* More accurately, 1800 years.

and that, in consequence of loss of vigour, decline inevitably sets in. It is, however, childish to estimate a phase of civilization by its achievements with the aeroplane, the big gun, and the submarine; rather we have to base our estimate on man's moral and intellectual achievements. It is tempting to dream of a future civilization under which the life of reason will at last be the life of mankind. There is, however, very little sign of permanent improvement in human nature, and it is perhaps a vain hope that the future will bring about such a favourable conjunction of circumstances as will lead to a civilization very much better than exists to-day.

Let us be honest and admit that our primitive barbarism is only dormant, and is ready to be roused into active savagery at the first beat of the drum.

2. Progress and Decay.

It has been said that Progress is the directing idea of humanity. Are we therefore justified in expecting a steady advance even though, physically and mentally, man has remained much the same for at least 100,000 years? Will our descendants of 100,000 years hence differ very much from ourselves? If so, how? Will they have made *progress*? In any given age, progress is presumably limited by the limitation of human faculty at that age. Any advance in knowledge and material conditions is always obvious, but real progress implies not only the development of public well-being but the development of the individual morally and intellectually, though the hypothesis of man's moral perfectibility does not seem to be supported by acceptable evidence. The theory of progress and the theory of decadence are equally defensible, and have in fact been held concurrently whenever men have speculated about their own origin, their present condition, and their future prospects. Listen to Mr. Bertrand Russell: "All the labour of the ages, all the devotion, all the inspiration, all the noonday brightness of human genius, are destined to extinction in the vast death of the solar system, and beneath the debris of a universe in ruins the whole temple of

man's achievement must inevitably be buried. All those things, if not quite beyond dispute, are yet so nearly certain, that no philosophy which rejects them can hope to stand."—This is pessimism indeed! but the logic is unanswerable, *provided* we accept a particular scientific hypothesis about the fate which awaits the solar system—and presumably the universe!

Both history and science give us warrant for believing that humanity has made great advances in accumulating knowledge and experience and in devising instruments of living, and the value of all these is indisputable. But they do not constitute real progress in human nature itself, and in the absence of any such progress those gains are external, precarious, and liable to be turned to our own destruction.

Novelty and Obsolescence are sometimes confused with Progress and Decadence. Innumerable things which were novelties to us thirty or forty years ago have now become obsolescent and have been put on the scrap-heap, or at best have been given a place in a museum. But do the things which have supplanted them indicate progress in any real sense? Labour-saving devices help us to live idler lives, but is man of the present day any happier, more intelligent, more humane, more moral, than his great-grandfather of a century ago? If not, how can it be said that he has made *progress*? The adoption of novelties does not necessarily constitute progress. The retention of obsolescent implements does not necessarily constitute decadence. How is an old-fashioned paraffin-lamp inferior to an electric-light, or a hansom-cab to a taxi? A saving of labour and a saving of time, perhaps. Yes, but do such changes indicate *progress*? Is there more progress in twentieth-century Europe than in ancient Athens? If so, how is progress to be defined? Who would dare to say that progress is to be measured by complexity of organization? Is not the group-mind, and sometimes even the mob-mind, the sort of mind that forms the springs of human action most frequently? And is not the present collective mind just an undisciplined and unsifted bundle of emotions and prejudices,

centred round sentiments rather than ideas, at heart as irrational as the collective mind of 2000 years ago? The queer incalculability of the mass-mind is not the only brick wall in front of us; there is the inertia of institutions, and there are the hard crusts of tradition.

Professor Whitehead has sagely declared that where an adequate routine, the aim of every social system, is established, intelligence vanishes and the system is maintained more or less mechanically and automatically. Specialized training alone is then necessary. No one, from Prime Minister to miner, need understand the system as a whole.

But the world is seething with unrest, and in order that we may obtain peace and comfort most of our would-be reformers would have us embrace some new form of economic faith. They formulate a creed and preach it with all the intensity and bigotry which in the past have characterized the struggles of religion, and this blind faith tends to smother the very last vestige of critical and analytical thought. They never mention the great intangibles and imponderables for which men die—those things which are verily immortal because they are a part of the soul of man himself.

3. Power. Discipline *v.* Liberty.

Nothing is more common than for even highly educated men to be imposed upon by the different acceptation of words. If, for instance, it were agreed that *justice*, not *law*, should be administered in the courts, or that no man can have a *right* to do that which is *wrong*, the ambiguity, which on careful examination is obvious in each case, is mischievous because it serves as an inducement to error. It is notorious that nearly all political terms are ambiguous. What, for instance, do we mean by *democracy*? Literally the term signifies government by the *demos*, by the *people*. But precisely what do we mean by the *demos*? A score of different people will probably give a score of different answers. What do we mean by *power*? Well, what form of power have we in our minds?

Do we mean the sort of power that a butcher has over a sheep or that an invading army has over a vanquished nation? Do we mean kingly power, parliamentary power, revolutionary power, economic power, power over opinion, the power of creeds, the power of organization, the power of competition, the power of a moral code, the power of science, the power of philosophy, the power of literature, the power of money, or what? Is there in our minds a vague agglomeration of all these things? Have we ever taken the trouble to ask ourselves exactly *what* we mean?

About a century ago the old political terms *tory* and *whig* gave way to *conservative* and *liberal*, two new terms, the main differentiating significance of which is still fairly obvious. But there has always been a tendency—at any one time a very slight tendency—for the different political parties in the State to veer a little to the left; the old tory die-hards have virtually ceased to exist, the modern conservatives are virtually identical with the liberals of forty years ago, and the modern socialists are virtually identical with the left-wing liberals—the radicals—of the same period. The old Disraelian tories used to swear by their ancestral homes and their emblazoned shields; the old liberals used to indulge in non-conforming and to assert their exclusive ownership of private property without social obligation; and the left-wingers dreamt of ultimate economic dictatorship. We may call the present conservatives, unionists or liberals; we may call the socialists, labourists; but the terms do not any longer matter. There are still two main parties, the go-slow party and the go-quick party, though both have accelerated a good deal in recent years. The left-wing of the socialists, the communists, blood-red as recently as the Spanish war, seem now to be fading gradually to a pink. All the parties, no matter what their colour or speech, together form a reasonably coherent “democracy”. The “people” appoint representatives through the ballot-boxes, and these representatives know well that it is their business to make the people happy and comfortable, to give them a minimum of work and to

provide them with a maximum of liberty and leisure. The last thing they dare do is to *drive*, except in wartime.

It is altogether wrong to think of "totalitarianism" as if it represented a new type of political *party*. It represents leadership by a trusted man, utterly ruthless and unscrupulous, who has no use for liberty or leisure. It does *not* represent any sort of class movement. There is no one class of the old type whose special interests Nazism or Fascism advances. Nazis and Fascists are admittedly in a minority in their own country, but in each case an outstanding leader has seized power. Both Nazi and Fascist seem to possess an extraordinary drive, a sort of psychological dynamism, which seems to be entirely lacking in those who try to resist it; in fact, opponents of the movements seem to feel that they are opposed not by men but by demons. Fascism and Nazism have succeeded in evoking from their devotees great stores of emotional energy which in their opponents are either latent or non-existent. In their own countries they can annihilate even the most widespread liberal-democratic opposition because those who believe in them "think with their blood". We reproduce three quotations concerning them culled by Professor Gilbert Murray. (1) "We do not know of or recognize truth for truth's sake" (the Professor of Philosophy at Heidelberg). (2) "What matters is not who is right but who wins" (Dr. Goebbels). (3) "The only good peace is a peace established by the victorious sword of a master nation" (Herr Hitler).

In thinking of the two opposing ideals—perhaps ideologies is a better term—which divide the world at the present time, we may safely ignore the differences of political parties. Neither need we differentiate between social classes: (1) the aristocracy who are rapidly flickering out except in the records of the College of Heralds; (2) the middle classes or bourgeoisie who have struggled up from below, are struggling for a place in the class above, and always keep an anxious eye on the markets; and (3) the working classes who now tend to look out upon the world through spectacles of less work and

higher pay.* And the main difference between rich and poor is also rapidly fading away. Even the difference between capitalism and socialism may here be ignored. We may, in fact, think of democracy as a single whole, as one of the warring systems into which the world is now divided. What is the fundamental difference between it and its rival totalitarianism?

Democracy is above all things clamant for *liberty*—liberty to criticize, liberty to argue, liberty to “go as you please”, liberty to be idle, liberty to be extravagant; it resents discipline, it tends to be intolerant towards its opponents, it abuses nations which do not think as itself does.

Totalitarianism above all things believes in *power* and in ruthlessly using it. Having once seized it, it is able easily to suppress any further exercise of the popular will. But it controls men not merely by force but by so subduing their minds that they desire to become mere instruments of the Government. It controls not only the Press and the Wireless but Education itself and so casts all people in the same mould. The cult of blind obedience to a leader supposedly superior in wisdom is inculcated in youth all day long and every day. People are kept ignorant of all facts in any way antagonistic to the ruling regime. The discipline imposed is a discipline of iron. The working-day is long and arduous, and yet the toil appears to be cheerfully undertaken. “Why,” ask the totalitarians, “should the idlers of the democratic states remain in possession of the riches of the earth, idlers who never work more than eight hours a day and then only pretend to work. *Watch* them at work. They even smoke at work. Examine their work when they have finished it. How we feel bound to despise them!” And in this way the Totalitarians, more especially the Nazis, are encouraged day in and day out to think of us.

That some of the caustic criticisms passed on the democracies are justified can hardly be denied. Can we in these islands any longer claim to be a nation of workers

* See the next chapter.

devoted to our jobs? It is true that the higher ranks of the British Civil Service have a traditional world reputation for industry and integrity, capacity, and devotion to duty, but is it not also true that the lower ranks of the service throw down their tools when the clock strikes,* just as the great mass of workers in other walks of life do? Is it not therefore natural that western continental nations should speak of us with some little contempt? Again, can we any longer claim to be thorough? Or, again, with all our national weaknesses have we any right to criticize our neighbours because their ways happen to be different from our own?

The ways of democracies are in sore need of amendment, but the very last thing they ought to do is to ape the totalitarians. Would life be worth living if we were kept in intellectual chains, if we were scoffed at when we dared to think, if we were put into a concentration camp and tortured if we dared to question the actions of our leader's myrmidons.

Is civilization doomed? Must Christian freedom be overwhelmed by a return to the brute violence of enslaving paganism?

Alternatively, can democracy cast off its sloth and its love of ease, borrow from its opponents what is worth borrowing, and give civilization a new lease of life?

Can some middle way be found? If so, can science help, or must it be thrust aside? The war of the twentieth century is no longer a war between science and religion; it is between science and the irrational forces which make for social degeneracy and disintegration.

4. Science: is it the Main Source of Power?

Primitive man could have known nothing of the marvellous destiny reserved for him, but a great moment arrived when a glimmering knowledge of the path which he was treading crossed the threshold of his consciousness. From this moment, instinctive striving began to be transformed into conscious

* I remember calling at a large Government Office one afternoon many years ago just as the clock was striking five. The pell-mell rush down the staircase of hundreds of clerks was startling.

and purposive action, and thenceforward man cherished hopes of being able to control the movement of his own progress. But this control has not yet been achieved, and it cannot be ours till we understand better the rationale of social evolution which has passed through so many successive phases. These phases are lines of direction which can be traced, and they must serve as signposts for the future. As Dr. Lyer has said, culture is a progressive movement which we can trace back to its beginnings in the evolution of man from lower forms. The discovery of speech, of the way to produce fire, and of tools, are among the most important points of new departure. From the age of stone we pass to the age of bronze and then to the age of iron, and so we go on to the invention of gunpowder, of the mariner's compass, and of printing. Half a century ago came the internal-combustion engine, which has been described as the greatest curse so far ever inflicted on the world.—Does such a description arise from prejudice? Every man finds it extremely difficult to free himself from prejudices which come from without, and probably impossible to free himself from those which come from within. We never become independent of our temperament. When therefore we learn that a great city like Rotterdam was virtually half destroyed in twenty minutes by bombs dropped from planes, must we plead guilty to prejudice when we curse the invention of the internal-combustion engine? In other words, is it a prejudice to blame *science* for the vast destruction at Rotterdam? Alternatively, should we admit that human civilization has not yet reached a stage when it can be entrusted with the use of such an invention, inasmuch as our savage instincts are still untamed?

Professor Bernal has instructively pointed out that when from about Renaissance time science began to develop seriously, Latin as the accepted universal learned language began to decline. One consequence of this was that there was henceforth no common linguistic medium in which new scientific knowledge and ideas could be expressed. Even now this language barrier is a very serious one, and there

still survive a number of separate scientific regions, most of them within a common European-American civilization, each region with its own scientific culture and outlook. The dividing boundaries are certainly not well-marked and they are shifting. The main regions are (1) the Anglo-American, Dutch, and Japanese. (2) German and central European. (3) French, Belgian and South American. (4) The Russian or Soviet. Each of these scientific regions has its own characteristics, closely associated with the contained national culture. The character of English science is essentially practical, concrete, and visual. It is fond of trying to conjure up the actual mechanisms by which nature works, and to make accurate models of them. English chemists have always made wonderful models of molecules, and physicists of fields of force; and some biologists venture to assert that they can actually see the strings of genes when they examine chromosomes under the microscope! In spite of such remarkable exceptions as Newton and Clerk Maxwell, British scientists as a class are not distinguished mathematicians, and the few that are have usually tried to interpret their equations in a clearly visualized concrete form. Even Newton was an experimentalist, and Maxwell's greatest friend was Faraday, the most resourceful experimentalist the world has ever known. On the whole, no other nation has ever reached the level of British science on the practical side. The general outlook of Americans is much the same, though the great natural resources of their country give them an enviable advantage.

We are bound to admit that in pre-Nazi days German science was at least the equal of ours, if not its superior. Even in the nineteenth century it was the fashion of universities in some countries to despise science, but almost from the first German universities fostered it and helped to organize it, and this was closely associated with State official recognition, which, however, certainly did tend to curb the freedom of prominent men of genius, who resented being machine-driven. In no other country in the world is science so successfully *organized* on a national basis as in Germany.

German chemistry is unrivalled. So is German military science. And yet the Nazis were stupid enough to drive out of their country such a world-genius as Einstein, merely because he happened to be a Jew. German prejudices are incomprehensible.

In France, science has passed its zenith but it has had a wonderful record. In recent decades the State has tended to treat it rather meanly. We must remember that the French as a nation are far abler mathematicians than we are. Anyone who is familiar with the mathematical attainments of the older boys in an English Public School gets one of the surprises of his life when he questions the boys in a French Lycée. And French science has always been famous for its wonderful lucidity of presentation. The distinguishing difference between our own science and that of the French is that our strength is on the side of applications while the French are primarily theoreticians. They formulate their equations and are sure that nature's secrets are contained in these; but they do not, as we do, try to convert the equations into models and pictures. Can we feel surprised that the French often smile at the pretty toys we make and show one another as if these truly represented nature's hidden secrets? How pretty is the architecture of British-made atoms and British-made chromosomes!

The science of the smaller European countries tends to follow that of one of the greater, though nearly all of them have produced original and independent thinkers. In Japan there is not yet much originality, but the Japanese are quick and clever and they are probably destined to do great things. And if the Chinese would only wake up! The masses of the Soviet union in Russia, too, are scarcely intellectually awake, but Lenin's foundations have already yielded an amazingly efficient national organization, and a generation or two hence Russia will be an exceedingly formidable neighbour. No one doubts the intellectual gifts of the Russians, dormant as these have hitherto been. Her science is far more likely to be original than to be copied.

No matter whether science is created and developed in this country or elsewhere, it brings with it at least one source of power with which it is not always credited. Ideas derived from science are, of necessity, predominantly of a transforming character, and the mere acceptance of them carries with it the implication that the present state of man is open to the possibility of an indefinite improvement. Science wields no greater power than this possibility of revolutionizing old ideas. The new ideas which emerge from the discoveries of science are, as a rule, predominantly practical in some form, and ultimately they are bound to have an influence upon social problems and therefore upon any particular national culture. But science tends to be austere, and to hold itself aloof from everything irrational and mystic, with the consequence that culture in all its humanistic forms often tends to repel even the friendliest advances which science makes. Science has, however, still to learn that human beings are much more irrational than they are rational. And culture, too, must step down from its pedestal; we may quote from Macaulay: "The ancient philosophy disdained to be useful, and was content to be stationary. It dealt largely in theories of moral perfection, which were so sublime that they never could be more than theories. It could not condescend to the humble office of ministering to the comfort of human beings."

Science has also exercised its power in another way almost as far-reaching if less subtle. When King Edward VII came to the throne forty years ago, there were no motor-engineers, no motor-mechanics, no taxi-drivers, no cinema industry, no air-pilots, no typists, no workers in synthetic materials, no electric-lamp makers. There has been a revolution in road and air transport through the invention of the internal-combustion engine, a revolution in power-production and power distribution, and a revolution in engineering and chemical technology through the invention of modern steels, alloys, and other materials. Suppose a defeated Britain were ordered by some kind of federated Europe to cease being a manufacturing country and to become a food-producing

country. Man's labour would be doubled and his wages halved. Think of the huge problem of the redistribution of the population, and the derelict towns! A revolution? Probably. But the prime cause of it all? Science? or man's greed?

5. Science: The Friend or Enemy of Civilization?

The Secretary of the Royal Society pertinently asks if science is to be blamed for the misuse which non-scientific people (that is, most of the world) make of certain discoveries. Who wants women in childbirth to die of puerperal fever as so many did before Pasteur made his discoveries? Who wants to return to the pre-anæsthetic and pre-antiseptic days of surgery? Who would abolish the means of transport by which fresh and healthy food is brought to us from the other ends of the earth? Who wants to stop the present world-wide research into the causes of cancer? And so with a thousand other things which civilization would now certainly refuse to do without. The novice might argue that biological research might be allowed to continue, but that any further research in chemistry, physics, and engineering shall be peremptorily forbidden. The suggestion is, however, palpably absurd. Before all things a biologist must be a competent chemist, a chemist must be a competent physicist, a physicist must have a sound knowledge of mechanics and mathematics. Anyone who is sceptical of the mathematical knowledge of present-day biologists should turn to the published works of Professors Hogben and Haldane. No researcher can tell what new discovery he may stumble upon when he is at work. If he happens to make a discovery which may be used by warmongers, or by those whose duty it is to defend themselves against warmongers, is he to be forbidden to continue?

Suppose that at some quite serious world conference it was proposed that war should be abolished, and that the only armed forces to be recognized in the world should be an armed police. Assuredly such a scheme ought to come within the framework of a modern civilization. But suppose the conference came down to concrete suggestions whereby

such abolition should be brought about, and it was proposed that every internal-combustion engine in the world should be destroyed and the manufacture be absolutely forbidden in the future. Think of it! the total disappearance at one fell swoop of all motor-cars, omnibuses, taxis, aeroplanes, submarines, motor-boats—the vast majority of things that move quickly on land, on water, or in the air. Nobody would listen for a moment. Destroy such a vast source of *power*? such a vast amount of *capital*? such a vast source of *comfort* and *convenience*? Give our civilization such an unnecessary setback? How plainly we can hear the arguments by which the proposer would be utterly crushed! And yet he would have taken us back merely to the beginning of the present century, to those happy and contented days of Queen Victoria's Diamond Jubilee.

A few years ago at Blackpool Sir Josiah Stamp referred to what he called scientific snobbery. "Many of the hard-boiled experimental scientists in the older fields look askance at the newer borderline branches of science—genetics, eugenics and human heredity, psychology, education, and sociology—the terrain of so much serious work but admittedly also the happy hunting-ground of cranks and faddists." We may readily grant the serious work, and the progress already made, but all these new branches of science are still in the cradle. What, for instance, do we really *know* about heredity? Practically nothing. Nearly everything is guess-work. Certainly we *know* that bodily mutilations are not inherited; we *infer* that intellectual ability is sometimes inherited for a generation or two; we *know* that there has been a great evolutionary advance during the last million years, and we tentatively *infer* what causes may have brought this about. And we *know* a great deal about stock-breeding. But when crank biologists come out of their laboratories, dabble in sociology and politics, and advocate human stock-breeding, sterilization of mental defectives and even of the unemployed, and make proposals for scientifically stamping out class-consciousness, they simply ostracize public opinion

and undermine the value of the serious teaching of their own subject. Scientists naturally take an interest in politics, as all men do, but their special knowledge gives them no right to set up as political dictators. Their training and their life-long use of methods which deliberately ignore human motives and prejudices certainly do not specially fit them to become the judges of what are the strong features and what the weak in human civilization. Let them remain neutral and show the world that they are scrupulously impartial judges of all newly ascertained objective facts, and that they do not claim to be able, any more than other intelligent men, to judge the springs of human action. Let scientists keep a watchful eye on the profit-makers, and do all they can to prevent their own labours from being used for base purposes.

It has been suggested that the training and education of men of science should be so modified as to make them both more competent to think rationally and impartially about the great problems of the day, and more alive to the human issues underlying the decisions which all men are called upon to make, but it is doubtful if much time can be spared for this additional work, lest the specific critical intelligence and exact scholarship which are demanded of them should suffer. All the world willingly admits that men of science, more than any other class of men, have special gifts for making objective inquiries and for forming objective judgments, but it does not admit they are less steeped in prejudices when they attempt to solve human problems.

Civilization has not yet reached the stage when the emotions can be controlled by the reason; for that we may have to wait even thousands of centuries. And at present we are in the grip of social forces in which the emotions simply run riot, and it is idle to talk of politicians being wicked or stupid. How are they to solve the paradoxical problem of starvation in the midst of plenty? Is any single remedy that has been suggested anything else but a nostrum? To talk of bankruptcy of mind and of leadership is to talk like a child. The problem has been attacked by some of the very ablest men we

possess, but it has not been solved and it seems to be insoluble. Germany and Italy have tried to solve it by methods of violence: have *they* succeeded?

Scientific advance has outpaced the slow march of civilization, and has created a completely new environment for modern life. Could a new school of political philosophy help, a school in which, as Sir Richard Gregory suggests, social problems are studied with the same independence that the experimental philosophers gave to their inquiries into natural phenomena and laws when they revolted against scholasticism three centuries ago? Is the time ripe for another Renaissance?

Can we learn *anything* from Germany and Russia? We cannot help hating some of their methods, but nobody can deny that both nations are awake.

In his admirable little volume of cautionary wisdom, *Spiritual Values and World Affairs*, Sir Alfred Zimmern indicates with great lucidity the pitfalls and dangers which beset the study of international affairs. He stresses the imperative necessity of clear and accurate thought if we are to realize a new world order which will adequately safeguard our heritage. He helps to construct a bridge across the chasm between science and humanism, and his suggestions should be carefully pondered over by all who seek to engage in the task of world re-construction. We are prone to forget that an increase in knowledge may mean only an increase of crude power ready for the use of a more ambitious tyrant even than Nero, and so herald a more complete collapse of civilization than that which overtook the Papacy and the Empire in the fourteenth century.

6. World Reconstruction: Utopian?

From those early days of civilization when men began to think seriously, attempts have been made to construct a new world-framework into which humanity and human desires might be fitted, fitted in such a way that its occupants might lead easy and effortless lives. Even the Christian Church

constructed a heaven in which men would be eternally happy because eternally idle.

What Utopias!

In a Friday evening discussion at the Royal Institution, delivered on 1st May, 1940, Lord Eustace Percy said that our success or failure in the forthcoming world-reconstruction would "depend mainly on the shrewdness with which we judge what really matters in civilization—what is unimportant enough to be surrendered, and what is valuable enough to be purchased. The civilized man always gets the best of his bargains, not because he has greater power of compulsion or persuasion, but because he has outgrown his taste for toys and does not mind parting with them—whether he is the trader bartering glass beads for rubber or the mediæval churchman granting absolution in exchange for land. Our danger is that so many trifles have still a superstitious value to one section or other of our democratic electorates: to the nationalist, mere territory: to the capitalist, his overseas investments; to the trade unionist, his control of the labour market by restriction of apprenticeship and prohibition of immigration."

The surrender of our old toys: yes, that is the question. Can we free ourselves from cherished old superstitions? Can we sacrifice our prejudices? Consider a single case. Suppose it were decided at a world conference that all people should use the same language and that henceforth the chosen language should be taught in every school in the world, so that at the end of, say, forty or fifty years the use of any other language would be strictly forbidden. And suppose that English were *not* the chosen language. How easy it is to imagine the heated arguments, the red-hot indignation, with which the suggestion would be met by English-speaking peoples! But *has* the English language—as a language—any real claim to priority, say over French, or Italian, or Dutch, or German? It is an extremely difficult language for any foreigner to master. It has practically no grammar: our grammar books are full of the artificial equivalents of foreign

inflections, particularly of French and Latin. No Western European language is so full of departures from rules and of abnormalities. Why *not* give it up, if a single world language would be such a tremendous contribution to world harmony? But such a surrender is inconceivable for another thousand years. We are at least as stubborn as any other nation about surrendering our superstitions and our prejudices, and we are as stupid as they are in putting the brake on any advances in civilization that are in any way likely to run counter to our own personal or national interests. What nonsense it is to say that, if the nations of the world eventually decide to adopt a single world-language, English should have the exclusive claim! English is so full of irregularities and is so unscientific, that its claims to become a world language are hardly worthy of serious consideration.

The late Lord Grey hated war, and as Foreign Minister he did his utmost to avoid war with Germany in 1914. When in spite of his efforts war came, he used these words: "The lamps are going out all over Europe; we shall not see them lit again in our life-time." Between 1918 and 1939 attempts were made to relight some of them, but they only flickered, and in 1939 they all went out again. How thick is the darkness into which the world is now plunged. When light comes once more, will Europe's diversity of peoples have been ironed out into a standard pattern of disciplined uniformity spoon-fed by a vindictive Germany? Or will international *laissez faire* be given another short lease of life? Or shall we be able to find some middle way, by which some measure of pooled resources and centralized control can be made acceptable, and European civilization thus be saved? But, even if this be possible, we must above all things remember, as Lord Halifax said in his address to the University of Oxford in February, 1940, "the fundamental claim of men and women is the free expression of personality, which rests upon the eternal value of every human soul."

On 21st July, 1940, the Prime Minister of South Africa, General Smuts, declared in a broadcast to Great Britain and

the United States, that Britain would prove to be an impregnable fortress. To the spectre of Nazi domination he opposed the vision of Europe reorganized and free. "Our vision still is freedom, the liberation of Europe from the deadly Nazi thrall and its organization is new creative freedom." Under a Nazi regime, "the units of Europe will be held together by central controls of Nazi ideology and Nazi economics, with the mailed fist in the background." "Real freedom, personal or national, will have perished. The principles of freedom of speech, freedom of thought, freedom of religion, and freedom of the Press, which have been the guiding ideals of the West will have been effectively suppressed. . . . As against this spectre of Nazi-dominated Europe, we oppose the vision of a truly free Europe. Freedom still remains our sovereign remedy for the ills from which human society is suffering. We envisage free Europe, free for individual and for nation. But we have also learnt that discipline and organization must go hand in hand with freedom. . . . As between nation and nation, there shall be the rule of law, the absence of force and violence, and the maintenance of peace. In such an international society there will be no room for self-appointed leaders and Führers. He who will be master shall be servant. Our aim and motto will be—A nation of free men and women; an international society of free nations."

Perhaps the saddest part of the conflict now raging is the betrayal of German youth by the enlistment of the honourable instincts of self-sacrifice and devotion in the service of a crudely materialistic philosophy adopted by a self-appointed ruffianly leader.

The key to many of the world's difficulties will be found when once we have more securely bridged the gulf between science and the humanities. We may quote Sir D'Arcy W. Thompson: "Science and the Classics! The one says (in Wisdom's words): They that eat of me shall yet be hungry. And the other says: They that drink of me shall yet be thirsty. And both alike continually enlarge our curiosity,

and multiply our inlets to happiness." And Sir D'Arcy reminds us that it has been the rule from time immemorial for science and the humanities to go hand in hand. Plato, the world's greatest humanist, was a mathematician and great philosopher; his pupil Aristotle, the greatest naturalist of his time, was also a great philosopher. Ptolemy, in his elation over his own work as an astronomer composed the following epigram (the translation is by Robert Bridges.

"Mortal though I be, yea ephemeral, if but a moment
I gaze up to the night's starry domain of heaven,
Then no longer on earth I stand; I touch the Creator,
And my lively spirit drinketh immortality."

Unshakable loyalty to worn-out creeds, no matter whether political, religious, educational, or social, or even scientific, is the incurable weakness of the British race. We are all far too much inclined to cling to a theory after changing conditions have made it obsolete. Is there any cure for such a national laggard mentality? It is very doubtful.

CHAPTER VII

Science and Education

1. Opinions of Distinguished Educators.

We use the term "Educators" deliberately, rather than Educationists.

1. Thomas Henry Huxley (1825-1895), one of the half-dozen intellectual giants of the Victorian age, thus expressed himself concerning Education: "That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear cold logic-engine, with all its parts of equal strength, and in smooth working order; ready, like a steam-engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to respect others as himself.—Such a one, and no other, I conceive, has had a liberal education."* Huxley crossed swords with some of the ablest men of his day, but not one of them ever drew his blood. I myself was one of two candidates to survive a written examination in Biology, and was then called up for a practical examination to be conducted by Huxley himself. I was fairly clean and expeditious with my two dissections, but there was an ominous growl when I failed to identify the fourth mounted

* *A Liberal Education*, p. 86.

microscopic section. Eventually, however, the growl was atoned for by a hearty handshake and a smile. Huxley could be kindness itself, but careless observation and slovenly reasoning always made him bite hard.

2. One of the best-known contemporaries of Huxley was Frederick Temple (1821-1902), Head Master of Rugby and later Bishop of London and then Archbishop of Canterbury. We may quote from an Essay he wrote when still Head Master, *The Education of the World*. "The youth, when too old for discipline, is not yet strong enough to guide his life by fixed principles. He is led by his emotions and impulses. He admires and loves, he condemns and dislikes with enthusiasm. And his love and admiration, his disapproval and dislike, are not his own, but borrowed from his society. He can appreciate a character though he cannot yet appreciate a principle. He cannot follow what his heart does not love as well as his reason approve; and he cannot love what is presented to him as an abstract rule of life but requires a living person. He instinctively copies those whom he admires, and in doing so imbibes whatever gives the colour to their character. He repeats opinions without really understanding them, and in that way admits their infection into his judgment. He acquires habits which seem of no consequence, but which are the channels of a thousand new impulses to his soul. If he reads, he treats the characters that he meets with in his book as friends or enemies, and so unconsciously allows them to mould his soul.

"At the meeting-point of the child and the man, the brief interval which separates restraint from liberty, young men are learning a peculiar lesson. They seem to those who talk to them to be imbibing from their associates and their studies principles both of faith and of conduct. But the rapid fluctuations of their minds show that their opinions have not really the nature of principles. They are really learning, not principles, but the materials out of which principles are made. They drink in the lessons of generous impulse, warm un-

selfishness, courage, self-devotion, romantic disregard of worldly calculations, without knowing what are the grounds of their own approbation, or caring to analyse the laws and ascertain the limits of such guides of conduct. They believe without exact attention to the evidence of their belief; and their opinions have accordingly the richness and warmth that belong to sentiment, but not the clearness or firmness that can be given by reason. The opinions now picked up, apparently not really, at random, must hereafter give reality to the clearer and more settled convictions of mature manhood. If it were not for these, the ideas and laws afterwards supplied by reason would be empty forms of thought, without body or substance."

"Toleration is the very opposite of dogmatism. It implies in reality a confession that there are insoluble problems upon which even Revelation throws but little light. Its tendency is to modify the early dogmatism by substituting the spirit for the letter, and practical religion for precise definitions of truth. Men are beginning to take a wider view than they did. Physical science, researches into history, a more thorough knowledge of the world we inhabit, have enlarged our philosophy beyond the limits which bounded that of the church of the Fathers. There are found to be more things in heaven and earth than were dreamt of in the patristic theology.

"To learn toleration well and really, it is absolutely necessary that it should break in upon the mind by slow and steady degrees, and that at every point its right to go further should be disputed, and so forced to logical proof. For it is only by virtue of the opposition which it has surmounted that any truth can stand in the human mind." *

It would not be fair to say that the Church held Temple in bondage, for at his death he had broken not a few out-of-date theological chains and had let light into many ecclesiastical dark corners. Temple was a broad-minded man, loyal to the Church but above all things loyal to the truth.

3. The former Dean of St. Paul's, Dr. W. R. Inge, writing on *The Training of the Reason*, said: "We have to convert the public mind in this country, to faith in trained and disciplined reason. We have to convince our fellow-citizens not only that the duty of self-preservation requires us to be mentally as well equipped as the Germans and Americans, but that a trained intelligence is itself 'more precious than rubies'. . . . As an instrument of mind-training, and even of liberal education, it seems to me that the teaching of science has a far higher value than is usually conceded to it by humanists. To direct the imagination to the infinitely great and the infinitely small, to vistas of time in which a thousand years are as one day; to the tremendous forces imprisoned in minute particles of matter; to the amazing complexity of the mechanisms by which the organs of the human body perform their work; to analyse the light which has travelled for centuries from some distant star; to retrace the history of the earth and the evolution of the inhabitants—such studies cannot fail to elevate the mind, and only prejudice will disparage them. They promote also a fine respect for truth and fact, with a wholesome dislike of sophistry and rhetoric. The air which blows about scientific studies is like the air of a mountain-top—thin, but pure and bracing. And as a subject of education, science has a further advantage which can hardly be over-estimated. It is in science that most of the new discoveries are being made. 'The rapture of the forward view' belongs to science more than to any other study.

"And yet science must not claim to occupy the whole of education. The laws of spiritual life are not the same as the laws of chemistry or biology; and the besetting sin of the scientist is to try to explain everything in terms of its origin instead of in terms of its full development: 'by their roots and not by their fruits ye shall know them.' The training of the reason must include the study of the human mind in its most characteristic products. Besides science we must have humanism, as the other branch of our curriculum."

4. Few men were so universally respected as the late Viscount Bryce, O.M. In his Introduction to *Cambridge Essays*, he wrote: "We in Great Britain have been too apt to rely upon our energy and courage and practical resourcefulness in emergencies, and thus have tended to neglect those efforts to accumulate knowledge, and consider how it can be most usefully applied, which should precede and accompany action. . . . It is upon the material things of this world, power and the acquisition of territory, industrial production, commerce, finance, wealth, and prosperity in all its forms, that the modern eye is fixed. . . . In some countries, as in our own, that which instruction and training may accomplish has been rated far below the standard of the ancients. Yet in our own time we have seen two striking examples to show that their estimate was hardly too high. Think of the power which the constant holding up, during long centuries, of certain ideals and standards of conduct, exerted upon the Japanese people, instilling sentiments of loyalty to the sovereign and inspiring a certain conception of chivalric duty which Europe did not reach even when monarchy and chivalry stood higher. Think of that boundless devotion to the State as an omnipotent and all-absorbing power, superseding morality and suppressing the individual, which within the short span of two generations has taken possession of Germany. In the latter case the incessant preaching and teaching of a theory which lowers the citizen's independence and individuality while it saps his moral sense seems to us a misdirection of educational effort. But in it education has at least displayed its power."—Lord Bryce wrote this in 1917, before the last war was finished. Were he to be writing now, how much more emphatic would he be!

5. Michael Faraday was perhaps the greatest physicist the world has ever known, and yet his knowledge of mathematics was utterly insignificant. No other man has ever seemed able to divine with such unerring instinct the working

secret of physical forces. Clerk Maxwell, one of the most eminent of Cambridge mathematicians, was a faithful disciple and friend. We quote from a lecture which Faraday delivered at the Royal Institution, where he was Professor of Physics. "The *self-education* to which a man should be stimulated by the desire to improve his judgment, requires no blind dependence upon the dogmas of others, but is commended to him by the suggestions and dictates of his own common sense. The first part of it is founded in mental discipline: happily it requires no mental avowals; appearances are preserved, and vanity remains unhurt; but it is necessary that a man *examine himself*, and that not carelessly. On the contrary, as he advances, he should become more and more strict, till he ultimately prove a sharper critic to himself than any one else can be; and he ought to intend this, for, so far as he consciously falls short of it, he acknowledges that others may have reason on their side when they criticize him. A first result of this habit of mind will be an internal conviction of *ignorance in many things respecting which his neighbours are taught*, and, that his opinions and conclusions on such matters ought to be advanced with reservation. A mind so disciplined will be *open to conviction upon good grounds in all things*, even in those it is best acquainted with; and should familiarize itself with the idea of such being the case, for though it sees no reason to suppose itself in error, yet the possibility exists. The mind is not enfeebled by this internal admission, but strengthened; for if it cannot distinguish proportionately between the probable right and wrong of things known imperfectly, it will tend either to be rash or to hesitate; while that which admits the due amount of probability is likely to be justified in the end.

"I will simply express my strong belief, that that point of self-education which consists in teaching the mind to resist its desires and inclinations, until they are proved to be right, is the most important of all, not only in things of natural philosophy, but to every department of daily life."

6. A former Master of Trinity, William Whewell, one of the ripest scholars Cambridge has ever had, reminded the world that Plato was a great mathematician and wrote over the gate of the garden of his Athenian school, *Μηδεὶς ἀγεωμέτρητος εἰσίτω*—Let no one enter here who is ignorant of mathematics. "And why this requirement," Whewell asked. "Why this prohibition? What was the need of geometry for his disciples? What use were they to make of it? What inference were they to draw from it when they had it? Precisely the inference which I have mentioned,—that there was a certain and solid truth; a knowledge which was not mere opinion: science which was more than seeming: that man has powers by which such truth, such knowledge, such science, may be acquired: that therefore it ought to be sought out, not in geometry alone, but in other subjects also: that since man can know, certainly and clearly, about straight and curved in the world of space, he ought to know—he ought not to be content without knowing—no less clearly and certainly, about right and wrong in the world of human action. That man has such powers, was the beginning of Plato's philosophy. To use them for such purposes was the constant aim of his mental activity. The impression which had been left upon his mind by the geometrical achievements of his contemporaries, and by those which he himself began, was, that the powers by which such discoveries are made are evidences of the exalted nature of the human mind: of its vast profundity; of its lofty destiny."

7. Herbert Spencer, our foremost Victorian philosopher, told his countrymen many home-truths, always in forcible language. We quote one. "Men who would blush if caught saying *Ipigénia* instead of saying *Iphigenía*, or would resent as an insult any imputation of ignorance respecting the fabled labours of a fabled demi-god, show not the slightest shame in confessing that they do not know where the Eustachian tubes are, what are the actions of the spinal cord, what is the normal rate of pulsation, or how the lungs are inflated. While anxious

that their sons should be well up in the superstitions of two thousand years ago, they care not that they should be taught anything about the structure and functions of their own bodies—nay, even wish them not to be so taught. So overwhelming is the influence of established routine. So terribly in our education does the ornamental over-ride the useful.” (*Education, Intellectual and Moral.*)

8. The President of Corpus Christi College, Oxford, Sir Richard Livingstone, in his presidential address on Education to the British Association in 1936, said: “ ‘ Read Horace and Homer, by all means,’ says Newman, ‘ feed ear and mind with their language and music; but do not expect to know their full meaning before you are forty.’ This truth, which Newman expresses in his exquisite prose, was well known to Aristotle. ‘ One may imagine why a boy, though he may be a mathematician, cannot be a metaphysician or a natural philosopher. Perhaps the answer is that mathematics deals with abstractions, whereas the first principles of metaphysics and natural science are derived from experience: the young can only repeat them without conviction of their truth, whereas the formal concepts of mathematics are easily understood.’ And again: ‘ the young are not fit to be students of politics, for they have no experience of life and conduct, and it is these that supply the premises and subject-matter of this branch of philosophy.’* The countries where students, not content with the theory of politics, take a hand in its practice, have a better knowledge of Aristotle’s meaning. But it will also be appreciated by those who have watched our own undergraduate students of philosophy playing a game of intellectual ping-pong with the Absolute.”

2. The Education of Nazi Youth.

Writing nearly forty years ago, before he became Dean of St. Paul’s, Dr. W. R. Inge pointed out that much of the scepticism of youth is due to inexperience of life, producing

* Eth. Nic. VI, 8, 6; I, 3, 5.

a simple conceit which we should be taking too seriously if we called it intellectual pride. The youth, when he first begins to think for himself, is a remorseless logician who is ready to argue out and decide problems of the utmost complexity, the deeper aspects of which entirely escape his notice. Sometimes our adolescent becomes a cynic who, it appears, has seen through all the shams and humbug of human society. He believes that people are actuated only by the most selfish and sordid motives, which they endeavour to conceal by means of hypocrisy. This is the most unamiable result of inexperience. But how much our beliefs are determined by our dominant interests! It was Marcus Aurelius who said that the soul is dyed the colour of its thoughts. We each of us make our own world by attending to some aspects of experience and neglecting others. The old dogmas which we learnt at school cannot help us unless we can find them within as part of our experience, and as Dr. Inge said, they must generally die before they can live again in this higher form: "for only by unlearning wisdom comes".

It is part of the Nazi creed to set on fire the mind of Nazi youth and to keep the fire replenished with the fuel of hatred, malice, and vindictiveness. All facts which seem in any way to run counter to that creed are ruthlessly suppressed, and Nazi youth grows into manhood utterly unconscious of human ideals outside the small circumscribed region of bitter hate and vindictiveness in which he has been nurtured. Probably never before in the history of the world has truth been so systematically and ruthlessly suppressed, and falsehood so sedulously fostered, as in Nazi Germany. German youth are being systematically encouraged to scoff at all creeds, theological, political, and social, which have not been created or at least officially approved by their Nazi leaders. For some ten years Nazi youth has been moulded in clay specially prepared by unscrupulous potters. Have they become efficient? Yes, highly efficient—for the performance of that particular little job for which they have been trained.

3. Socialism v. Individualism.

It was a former Master of Balliol (Edward Caird) who pointed out that, for most men, the influence of the opinion of the particular society amongst whom they live is almost irresistible, though it is so continuous and unvarying that they are often least conscious of it when they are most passively yielding to it. Yet if we look carefully around on our political and social life, we cannot help seeing that the one thing needful is to find some method of uniting what is good in Socialism and what is good in Individualism. On the one hand we desire to make men members one of another, without interfering with the free development of individual life, or with the vigorous struggle of interest, powers, and ideas, which is necessary for their development. On the other hand, it is to make men free, independent, responsible makers of their own lives without wasting their energy on a ruinous competition, and narrowing their souls by mutual jealousy and hate. Everyone who is not the victim of an abstraction must recognize that each of these interests is essential to us, that neither can be pursued to the exclusion of the other, without losing much of its own value.

Men have sought unity in ways which involved the suppression of the individual, and the emancipation of the individual in ways which involved the sacrifice of social unity. But the results show that each end when separated from the other, loses its own value and meaning. The unity that is secured at the expense of the individual independence of the members of a society tends more and more to become an external and mechanical bond, a bond which binds together men's bodies but not their souls. Germany is now held together by such bonds. One man thinks and wills; all other Germans are at present virtually his slaves. But some day Germans will learn to think again.

Another distinguished Balliol man was Matthew Arnold the son of the famous Head Master of Rugby. He was a fine

scholar, a poet, and an essayist, he became one of H.M. Inspectors of Elementary Schools, and he was ever an open admirer of German thoroughness. Not the least interesting of his books was *Culture and Anarchy*, in which he divided up the British people into three main classes, "Barbarians, Philistines, and Populace". By *Barbarians* he meant the aristocracy, a class which is lured away from following light by worldly splendour, security, power, and pleasure. In this country we have never had the prejudice against our aristocracy that prevails amongst the races of Latin origin. The British aristocracy possess that staunch individualism, and that passion for the assertion of personal liberty, which is perhaps the central idea of English life. Their care for all manly exercises and for their physical well-being, the vigour and the striking physical appearance which by these means they have acquired and perpetuated in their family, their exquisite manners and distinguished bearing—all this culture is of an exterior type, almost exclusively. It consists principally in outward gifts and graces, as manners, accomplishments, and prowess. Their chief inward gifts are courage, high spirit, self-confidence. But their most noteworthy characteristic is their natural inaccessibility to ideas. Their intelligence is limited. They have little soul.

The term *Philistine* Arnold used to convey a sense which makes it curiously appropriate to our middle class, inasmuch as it suggests the notion of something particularly stiff-necked and perverse in its resistance to sweetness and light. The aristocracy conceived of as a body extend from the chivalrous lord to the defiant baronet, and then comes the deep ditch which the belted knight, be he ever so agile, usually fails to jump over. He remains a member of the middle class. Still, these are days when the middle class man is becoming uncommonly agile.

Bordering the lower end of the middle class is another ditch, almost as difficult to get over from its far side as is the one at the top. Below this second ditch is Arnold's third class, the Populace, which devotes all its energies to organ-

izing itself, through Trades' Unions and other means, in order to establish, first a great working-class power, independent of the middle and aristocratic classes, and then, by dint of numbers, to reign absolutely. It is wholly occupied with things of itself and is now asserting an Englishman's heaven-born privilege of doing as he likes, meeting where he likes, bawling what he likes, breaking what he likes.

Arnold's three class distinctions are still conveniently, if roughly, indicative of the three main grades of the British people. Though still outwardly antagonistic towards one another, each possesses more than a suspicion of the deeper nature of the other two, and in times of stress all three promptly close their ranks and stand shoulder to shoulder. Duke's son, parson's son, and cook's son are ever ready at such times to become close comrades. It is true that as a nation we are prone to be too clamant for our "rights", too forgetful of our "duties"; we may shout for a maximum of the former and we may evade doing more than a minimum of the latter. But we never shrink from joining forces in doing battle with the common enemy.

4. Science as a whole now too vast for any one man to master.

The advance of science during the last thirty or forty years has been so rapid that not even the most brilliant worker in its field can claim to be master of more than a small fraction of it. As Professor Levy says in his *Modern Science*, every branch of science has its intervals of growing instability, until finally, with almost catastrophic suddenness, it casts off its outworn theories that are no longer capable of accommodating the growing mass of facts. With a new synthesis comes a new lease of scientific life. We can see the same process at work in science as a whole. Beginning on a single front as one study, it has steadily and persistently split itself up into a succession of specialized sections. With this process there has evolved, as Professor Levy says, the tradition that no scientist who values his reputation ought

to trespass on a field outside that of his own specialism. The language in which specialized monographs are now written, the symbols, sometimes even the fundamental notions on which the theories are erected, are almost incomprehensible even to other scientists, and entirely incomprehensible to all laymen. An exhaustive synthesis of modern scientific ideas now seems to be beyond the reach of any living man. Almost every present-day distinguished man of science seems to be paddling about in his own tiny little pond.

A noteworthy new book, but one which tends in some ways to repel not a little, is Professor Lancelot Hogben's *Science for the Citizen*. He says: "A course of general science adapted to the requirements of citizenship should be orientated towards the elucidation of the major constructive achievement of natural knowledge in the evolution of civilization. Among the cardinal themes which thus replace the arbitrary division of science into separate 'ologies', those which claim special attention are the construction of the calendar, the technique of navigation and map-making, the extension of deep-shaft mining, the exhaustion of food supplies, the introduction of inanimate and mobile power, the discovery of chemical fertilizers, the principles of scientific breeding, the control of epidemic diseases, and the national dietetic minimum. School science should not be a selection from the competing claims of specialist disciplines. It should be the story of man's conquest of time-reckoning and space-measurement, of the search for materials and substitutes, the liberation of natural sources of power, and the struggle against hunger and disease. When it becomes this, the theoretical principles which have the greatest yield will emerge far more clearly."

In the course of a weighty review of this book, *The Times** remarks: "It may be argued that among the major ills of our society is a failure to adapt itself to the new knowledge and the new opportunities which developing science offers.

* *Educational Supplement*, 15th June, 1940.

In the educational field this is partly responsible for the feeling of unreality about a great deal of what is learned, the feeling that it is academic and remote from life. A good deal of the idealism of nineteenth century education has evaporated because it has not been realized that the new renaissance (for such it is) has put within our grasp infinite new possibilities for constructive social effort." It is the "consideration of science as a social activity that is Professor Hogben's greatest contribution, and it is here that school science teaching has most to learn from him". But the reviewer is also sharply critical: "the tone of much of the contents is calculated to rouse gratuitously the antagonism of many of his readers. It is lamentable that the author alienates the very people whose support is most essential by the intolerance and distrust towards our whole educational and social tradition."—It is unfortunate that such an able man as Professor Hogben should be so lacking in persuasive sweetness. We are a pig-headed race, as our enemies know so well. As the Yorkshire man says, and as the Sussex man reiterates, "The Britisher will not be druv." Had the Germans thought of using a little sweet reasonableness, instead of whips and scorpions, how much they might have squeezed out of our softened selves!

5. A British Weakness: Illogical Reasoning.

British people can do many things, and can do them well, but few of them can reason logically. We are certainly not a mathematical people. In a French school or in an Italian school the mathematical progress of the average pupil is far and away ahead of that of the average pupil in an English school. A small minority of our pupils become capable mathematicians, but only the few ever reach a respectable standard. Listen to debates in our House of Commons. How verbose and illogical some of the speakers are! Strip their speeches of all flowery language and reduce the remainder to a series of logical syllogisms. How thin the fare often proves to be! The listener is driven to the conclusion

that the speaker when at school was a shirker during his mathematical lessons.

One of the very ablest of the world's mathematicians is Professor A. N. Whitehead, as those of us who have struggled through his *Principia Mathematica* * have found out. In his delightfully lucid and suggestive book, *The Organization of Thought*, he says: "The art of reasoning consists in getting hold of the subject at the right end, of seizing on the few general ideas which illuminate the whole, and of persistently marshalling all subsidiary facts around them. *Nobody can be a good reasoner unless by constant practice he has realized the importance of getting hold of the big ideas, and of hanging on to them like grim death.* . . . It is untrue to say that when we know the premisses we also know the conclusions. In arithmetic, for example, mankind are not calculating boys. Any theory which proves that they are immediately conversant with the consequences of their assumptions must be wrong." It is much to be regretted that such a large proportion of the boys in our great Public Schools have done so little mathematics. In later life their reasoning tends to be slipshod, their statements inexact and unconvincing, their intended meanings doubtful.

6. The Hebrews and the Greeks as our Mentors.

It was a famous Russian thinker who referred to the Hebrews and the Greeks in this way: "In His care for the human race before the coming of Christ, God gave to the Hebrews law and to the Greeks philosophy. Law says 'you must', or 'you must not'; philosophy asks the questions, 'why?' and 'for what purpose?' Thus we mark a difference in the attitude of the Creator towards the chosen peoples. The Hebrews he ordered, with the Greeks he reasoned." What an enormous intellectual debt we owe to these two ancient peoples! Between them they taught us the real nature not only of the law but also of the true, the beautiful, and the good.

Taken in its narrow sense, truth simply means that, in

* By Whitehead and Bertrand Russell, 3 vols.

speaking, we should never wilfully misrepresent the picture impressed on our memory by our vision, our reason, and our powers of reflection. In the wider sense, truth includes the demand that the picture shall correspond as nearly as possible with reality. The first condition apart from the second is almost useless. It is the second, the *feeling* for truth, that the school should strive to develop, for the task is beyond the power of the family. In the family circle, a boy is continually hearing hastily formed judgments, dictated by sympathy or by antipathy; he grows accustomed to train his own judgment in the same easy-going fashion. The school and the school alone can teach him how he must work in order that his judgments may conform to truth.

A capacity to change one's opinions for intellectual reasons, that token of mental freedom and mental progress, is the most precious inheritance left to us by ancient philosophy. However unpleasant for us, we must accept a decision once it is proved; however dear to us, a conviction must surrender once it is refuted. This is the thinker's code of honour.

Physically beautiful men, the glory of the ancient Greeks, are merely an anachronism now; and physically beautiful women are rapidly becoming an anachronism likewise. It is the educated mind that is now the pivot of attraction. A mere model in clay may be a thing of exquisite external beauty. But within?

7. Education: Present-day Tendencies.

A well-informed foreign correspondent writing to *The Times Educational Supplement* drew an interesting contrast between the Continental day-schools and the English Public Schools. "In Continental day-schools the boys lead their own private lives—their own ego is the centre of their thoughts and their existence." "In the English boarding-house system the boy is taught from the first day to fit into the community, to respect the feelings of the other boys—if he wants his own feelings and weaknesses to be respected. By the prefect system some boys learn to respect the responsibility of somebody of

their own rank; the others learn to exercise this authority, to have responsibilities not only towards the head master and masters but towards the other boys.”—It is not fair, however, to place these two classes of schools in such a contrast. It would be more to the point to compare the Continental day-schools with the great English day-schools. The English Public Schools stand almost alone, and must be judged on their own merits. We may consider for a moment the same writer’s opinion on the teaching of English in the English Public Schools.

“English examinations—school certificate, higher certificate, and scholarship—consist usually in answering six to eight questions out of ten to twelve in three hours. The best a boy can do is to reproduce what he learned; he has far too little time to concentrate on style or language, or even to elaborate some idea of his own.”

“This kind of examination affects naturally the way of teaching and syllabus. A foreigner is amazed to see how little English is taught, and how differently it is taught from the way the French, for instance, teach French in their schools. In French schools, at all stages of the school, French is and remains a main subject—French language and grammar, literature and poetry, history and thought. The French have their own remarkable way of text-reading—the *explication de texte*. They take a certain passage of a text, analyse it: they show to the boys the reason why the author chooses particular expressions and words, they try to make the boy understand the author’s way of thinking, to appreciate the beauty of language and the logic of thought. The result is that most French boys acquire not only a perfect knowledge of their own language, but master it, and are capable of thinking for themselves. In English public schools the teaching of English certainly seems neglected. Moreover, the text reading consists too often in a plain reading, and asking the boys in their own, often distorted, way, to repeat what they read in a perfect language.”*

* See the articles “In Praise and in Defence of Public Schools”, *Times Educational Supplement*, 4th and 11th May, 1940.

We are bound to admit that the French know their own language, and appreciate its niceties of meaning and its beauties, far better than we do ours. And they are unquestionably better mathematicians than we are. Other subjects? Doubtful. On balance I should shrink from advising far-reaching changes in our own system.

Here is a picture of English Public School life drawn during the war-period, 1914-1918: "It is the public schoolmen, grumbling at their work, who govern the Indian Empire with resentment of praise from others and no thought of praising themselves. Versatile, light-hearted, infinitely resourceful if cholera sweep the land, they will step from one dead man's shoes to another's and leave a village in order to govern a province. Haggard and drawn with long weeks of eighteen-hour days, they will yet find time to mistrust the man who is not of their race or speech or school, and growl at him who offends by his clothes or enthusiasms or aspirates."

At that time the opinion prevailed that the ordinary Public School, so far from tending to develop individuality, tended to destroy it and to reduce all its pupils to a conventional type. "Herded together in the close relations which are the essential conditions of their existence, boys must conform to pattern if they are to survive. The pattern is a good one, but it is a pattern; and the atmosphere which permeates the whole of that close, self-satisfied, inexperienced society is antagonistic to the development of individuality. The training of the Public School boy has made him intolerant in thought, and narrow in his views; he thinks that mankind can only be regenerated by his order. Yet who are the men who are governing the Empire to-day in times of stress which have no parallel, who are the men upon whom the nation as a whole has pinned its confidence? *Not* the men who have been reduced to a pattern at the Great Public Schools."

And the leaders in the present war? The Prime Minister, Mr. Winston Churchill, was a boy at Harrow, and thirty to forty years ago I heard many interesting stories from masters

who had taught him there. "Defeat," the boy never experienced and never understood: how *could* the descendant of the famous victor of Blenheim, Ramillies, Oudenarde, and Malplaquet, understand such a term! No doubt Harrow taught him much, but he taught Harrow more. What a happy blend of Britain and the States he has proved to be! He is as resourceful as he is unconquerable. And his half-dozen present chief Cabinet co-adjutors: are *they* moulded to pattern? Consider their resourcefulness, their strenuousness of effort, the dignity of their intellectual work, their conception of the value and power of knowledge: how immeasurably superior are their ideals above those of the rank and file of our great boarding schools! One disadvantage under which the boys labour at a great boarding school is that expert and ready help from highly competent masters is always available; the boys are not thrown enough on their own resources; they must be moulded to pattern. Let it be granted that the pattern is often excellent, but think of the sacrifice of originality! In the great day-schools, e.g. the famous schools in Manchester, Birmingham, and London, there is far greater independence of spirit and of effort, the boys are more resourceful; personality is not subordinated to mechanical pattern, but is carefully and independently developed. At bottom, the present war is but an episode in the eternal struggle between soul and body, and all the world is of opinion that we are engaged in a duel to the death with the materialism of Germany. *But are we ourselves quite free from the materialism which has eaten into Germany's heart?* How verily poor are our money-hunters who have so signally failed to appreciate the things of the mind and spirit, to whom the true, the beautiful, and the good are never more than faint shades of passing shadows. Assuredly it is time for us to lift up our hearts and cry for help. Dare we refuse any longer?

In his *The Twenty Years' Crisis, 1919-1939: an Introduction to the Study of International Relations*, Professor E. Hallett Carr points out that the fundamental difficulty of

reconciling the good of the nation with the good of the world community is due to the breakdown both of (1) the Darwinian doctrine which not only identifies the good of the whole with the good of the fittest but also contemplates without repugnance the elimination of the unfit; and (2) the doctrine of a natural harmony of interests which has lost such foundation in reality as it once had and has inevitably become a cloak for the vested interests of the privileged. Sir Alfred Zimmern has pertinently pointed out that the transition to a durable peace and a more equitable social order must be in the sequence (1) order, (2) law, (3) good government, not conversely. It was Lord Halifax who in a broadcast last autumn insisted that "no paper plan will endure that does not freely spring from the will of the people who alone can give it life." And it has been well said by an authoritative writer in *Nature* that the world commonwealth of the future can be held together only by a world loyalty and the invisible bond of ideals, and the problem of building world order on a lasting basis belongs in the long run no less to psychology and to education than to politics and economics.—That is certainly true but the much wider truth is that the subject of psychology regarded as a science is really still but an infant mewling and puking in its nurse's arms, and apparently it is going to take another century to reach responsible manhood. No people on the face of the earth seem to wear so thin a veneer of civilization as do the Germans: they are the same cruel-at-heart and cruel-in-action Huns as they were in the old Roman days. There lies the world's danger. Outside Germany the tendency of education is to become an instrument of rational propaganda and to promote a spirit of independent inquiry. The more rational the methods by which propaganda is conducted, and the more it is in line with the rights and interests not of the individual, not even of a class or even of a nation, but of the whole world community, the more likely is it to be effective. A single nation blocks the way to the completion of humanity's civilizing progress. The pity of it!

Considering how systematically science has been taught in all grades of Secondary Schools during the last thirty or more years, the great Public Schools included, it is remarkable how profoundly ignorant of the subject most educated people seem to be. I have known quite intelligent people confuse electrons with genes, and nebulae with asteroids! And I know not a few eminent men of science whose outlook on life is curiously a-moral and a-cultural: they are simply not intelligently interested in anything which is not contained in their own special little boat which they paddle about in their own little pond. And yet the belief is almost universal that the future of the world depends very largely upon the fusion of the opposite camps. But how is the fusion to be brought about? Many distinguished men of science are simply not educated. At school they showed early promise of doing well in physics and chemistry and thereafter practically became science specialists, at any rate in the Sixth Form if not before, and at the university they had little interest in anything outside their own little chosen field. On the other hand many men who have distinguished themselves in literature or history are profoundly ignorant of everything appertaining to science. The two sets of men live in different worlds and each tends to be intolerant of the other. Which set is really educated? Either? or neither? How badly the world is in need of men who really know something of the world as a whole! For thirty years Education Authorities, Central and Local, have been doing their best to produce such men, but alas! without success. British prejudice is exceedingly difficult to eradicate. It is as deep-rooted as German cruelty.

It is an interesting fact that since the war of 1914-18, such a large number of people have attached so much value to the teaching of science, apparently being of opinion that such teaching confers on pupils and students knowledge and intellectual power of an altogether higher type than, say, the teaching of history or of literature. Such an opinion is palpably absurd. Even eminent men of science are prone to use abstract nouns for the things they talk

about, e.g. "*science* is a-moral". (This is not one whit better than thinking of the "State", not as an assembly of people but as some unseen Being that resides in the background, a Buddha-like abstraction to whom one has merely to make fervent appeals.) For such foolish fallacies the early specialized teaching of science paves the way, and the pupil's mind—his soul—is left almost without development. As he passes from adolescence to manhood his moral sense may even become atrophied because of the removal of many of his earlier cherished beliefs: he becomes highly efficient it is true, but his efficiency is mechanical. How sterile is the mind of a boy who is allowed to begin to specialize in science and mathematics at about fourteen or fifteen.—Are such boys *educated*? They have had virtually no *cultural* training at all. Their minds are barren, except for the little unripe fruit they gathered as small boys from their Latin cribs, and yet such barren minds may dare to have views on, say, the delimitation of social strata.

It was that original thinker, Matthew Arnold, who pointed out that in all branches of knowledge it is the business of the *critical* power to see the object as in itself it really is. Then it tends at last to make an intellectual situation of which the *creative* power can profitably avail itself. It tends to establish an order of ideas which will prevail, though these the average Briton tends to dislike, because to him rational and logical ideas seem to interfere with his politics. A conservative is always right; a socialist is never wrong. Arnold points out that the word *curiosity*, which in other languages is used in a good sense and means a high and fine quality of men's nature, a disinterested love of a free play of the mind on all subjects, in our language has no sense of this kind but always signifies something bad and disparaging. Real criticism obeys an instinct prompting it to try to discover the best that is known and thought in the world, irrespective of practice, politics, and personal whims. And it is this particular feature on the classical side of our great Public Schools that makes Sixth Form work so invaluable.

8. The Future of the Public Schools.

In a persuasive and thoughtful leading article, *The Times (Educational Supplement*, 10th May, 1941) spoke thus:

“The public schools are rightly proud of a long and distinguished tradition, and they not unnaturally tend to cling tenaciously to a status and to privileges that went for long unchallenged; but there is evidence that some at least of their sons realize that the foundations of privilege are not constant but change with changing conceptions of society and the common weal. The State educational system, on the other hand, a child of later birth, is becoming increasingly conscious of a sense of vigorous growth and great achievement, but mingled with the satisfaction that sense conveys is an uneasy awareness that maturity has not yet been reached, and a growing conviction that it never can be reached until certain restrictive limitations of both its constitution and its philosophy are removed. The constitution can be altered by legislative action alone, and this is already promised if not yet in sight; emendation and expansion of the philosophy can best be sought by assimilation of a parallel yet not coincident philosophy. Some will of course deny that the public school philosophy has anything of value to contribute to that of the state system, and others will maintain that the impress of the former is already too clear upon the latter. But there is the world of difference between assimilation and impression, and the quality of the contribution has yet to be tested in conditions of co-operation.

“The incorporation of the public schools into the State educational system would involve for them great sacrifices—intangible but none the less real—and the fact that they would in many instances reap correspondingly great material benefits would not necessarily eliminate nor even diminish the pain of sacrifice. By its very nature democracy cannot demand this sacrifice of them, but equally because of its nature it knows how to accept and profit by its offer, and the schools would

never be more true to their tradition than if they came voluntarily and willingly to the nation and placed themselves unreservedly in its hands, to take and to use as it thought best. Can they rise to the height of this opportunity? Can they see that, important though their contribution to English education may have been and is, the time has come when they can no longer remain what is now its main stream, and at the same time profess the tenets of democracy? That it is not truly democratic merely to offer to share tradition and privileges upon conditions of continued isolation and exclusiveness, but that modern democracy implies that all shall be offered unconditionally for the benefit of all? It is difficult to believe that the opportunity will not appeal to all that is best in the public school ethos."

CHAPTER VIII

Science and Religion

1. Fields of Experience: different impressions on different minds.

Different persons surveying precisely the same field of experience will form different impressions. The tendency of the religious man is to worship, of the artist to admire, of the man of science to observe, and from the same world of facts each of the three therefore tends to make his own selection. The same person may, it is true, be at once religious, artistic, and scientific, but he will probably tend to drift along with his pet prejudices at least a little, and will see certain of the facts thrown up in relief above all the other facts, viz. facts of the type and range which have always seemed of special interest because to him easier to observe and analyse. To most of us certain things are undoubtedly easier to observe and analyse than others; certain things are easier to admire and contemplate with satisfaction than others; and certain things are much more easily renounced than others. Thus, though when we generalize we have to say that the field is one and the same for science, art, and religion, when we begin to grapple with this field in all its complexity we find that in practice there are three fields which overlap. It is as if the same field of general experience became organized in three different ways round three different centres of interest, science, art, and religion. The three attitudes of mind in which we approach the world of common experience seem to select parts of this world for special attention. But selection is really a valuation, for we cannot select one thing from

among a number of other things without assigning it a higher value than the others. What the mind tends to concentrate upon becomes, for that very reason, its most important fact, and the one in terms of which all the others gain or lose importance. For instance, the scientific attitude selects as central those facts of experience which are most clearly and accurately observable, that is to say, what can be measured and counted. They become for it the most important facts in the world. Science selects the measurable aspect of things as the most important because it is the aspect with which it can deal most satisfactorily.

I believe it was the late Lord Balfour who said that no man of science *really* supposes, though sometimes when burning the midnight oil he sleepily brings himself to assert, that he personally is nothing more than "a changing group of electrical charges", so distributed that their relative motions enable or compel them in their collective capacity to will, to hope, to love, to think, to treat themselves as a mental unity. It is, however, true that the immense advances which in modern times have been made by mechanical explanations of the material world have somewhat upset the mental balance of many thoughtful persons who approach the problems of reality exclusively from the physical side. They tacitly suppose that every discovery, if genuine, will find its place within the framework of a perfected physics, and, if it does not, may be summarily dismissed as mere superstition.

But what are we to say about a universe reduced without remainder to collections of electric charges? To set limits to reality by eliminating the spiritual is not only hazardous but contrary to reason. For if we are aware of anything it is of ourselves as personal agents. We can certainly act on our environment, and as certainly our action can never be adequately explained in terms of entities which neither think, nor feel, nor purpose, nor know.

Assuredly in the present state of our knowledge, as Lord Balfour so logically and convincingly pointed out, we have

no choice but to acquiesce provisionally in an *unresolved dualism*. Our experience has a double outlook. The first is rightly called *material*. It brings us face to face with such subjects as electricity, mass, motion, force, energy, and with such manifestations of energy as ethereal radiation; it deals with objects which are measurable, calculable, capable (up to a point) of precise definition. The second is *spiritual*; it deals with the immeasurable, the incalculable, the indefinable, and with our minds, with our wishes, our hopes, and fears. The first touches the fundamentals of science; the second is intimately connected with religion. Yet different as they seem, both are real. They belong to the same universe; they influence each other; and somewhere and somehow *they must be in contact along a common frontier*. But where is that frontier to be drawn? And how are we to describe the relation between these coterminous provinces of reality? Alas! at present there is no answer.

It was the same distinguished man who, when a commoner (Mr. Arthur J. Balfour) and long before he became Prime Minister, had pointed out how it had been said that the discovery of Copernicus was the death-blow to Christianity, for the discovery had forced the human race to recognize what an utterly insignificant part the planet earth plays in the cosmic drama and seems to render the Incarnation intrinsically incredible. This was not a question of logic, or science, or history; no criticism of documents, no haggling over natural or supernatural, either creates the difficulty or is able to solve it. For it arises out of what we may almost call an æsthetic sense of disproportion. Those whose studies bring perpetually to their remembrance the immensity of the material world, who know how brief and utterly imperceptible is the impress made by organic life in general, and by human life in particular, upon the mighty forces which surround them, find it hard to believe that on so small an occasion this petty satellite of no very important sun has been chosen as the theatre of an event so solitary and so stupendous. How utterly, utterly, insignificant is the earth

—our own petty little world—to have any sort of claim to be playing a part of any appreciable significance in the stupendous cosmic drama.

Metaphysicians have usually desired something more rapid and final than a truth that revealed its value in experience and thus only very slowly hardened in the service of man. They have insisted that a truth to be true must, as Schiller puts it, leap into being like Athene fully armed, and be absolutely true from the moment of its birth, and without waiting upon experience. So they have preferred to launch upon the world each an *ipse dixit* of his own, and have claimed for it self-evidence and a *priori* truth. Naturally enough they resented any demand for a testing of such claims by the working of these in experience. And they have overlooked a point of capital importance. An assertion can never be accepted as fully true until it has been tested. But whatever can be tested can also be contested. It follows therefore that, strictly speaking, there can never be such a thing as a truth *a priori* in need of no test and open to no cavil.

It was Cardinal Hinsley, Archbishop of Westminster, who, on the Day of National Prayer, 26th May, 1940, said: "Peace has been murdered between nations because the party in power in Germany has avowedly cancelled truth from its programme, and has declared that our traditional Christian civilization is to be shattered by the might of the immortal Nordic race. For years past the youth of the German nation have been trained to use the discoveries and inventions of science, the fruits of industry, all their energies and talents, for the glory of total warfare. The gospel of pride and hate has been loudly preached to a large receptive audience, unhappily comprising the mass of the German nation. Now Christians understand. No liberty is possible, no decency in human life, if a pagan people may subdue by its fury, and scourge with scorpions, the rest of mankind." The Cardinal was but one of many eminent men who spoke to the same effect on the same day. The remarkable unanimity was good evidence of the feeling of moral

revulsion aroused among religious leaders of all faiths by the debased Nazi regime.

2. Miracles and Science.

In the last quarter of the last century, not a few highly educated men sometimes evinced a feeling of suspicion, even of repulsion, towards science; this feeling was not always conscious, it was often merely instinctive, and was probably often due to a distaste for the systematizing habits of mind of scientific thinkers, which are alien to those more intuitional modes of apprehension that are congenial to thinkers in many other fields. But the feeling is also largely due to a fear that the scientific view of the world leaves no room for the domain of freedom, for theological conceptions, or generally for the spiritual order of things.

Half a century ago a great controversy arose ostensibly concerning the problem of miracles, the principal protagonists being T. H. Huxley, Julian Huxley's famous grandfather, and Dean Wace of Canterbury. But it is now clear that the root of the controversy was, as Professor Dingle so clearly points out, not the credibility of miracles at all, but the status of the Bible as a record of matters of fact—the interpretation of holy scripture (1) as an impregnable rock or (2) as an imperfect human document. Few intelligent people would maintain nowadays that miracles are necessary for the full recognition of Christianity. If miracles had been omitted from the records of the evangelists there would probably have been no serious difference in the religious views of Christians, and we know now that Christians who have learnt to realize that their faith is not indissolubly bound up with the infallibility of the Bible are not inclined to attach any serious importance to miracles.

3. Agnosticism.

There is a fundamental difference between an atheist and an agnostic. An atheist positively *denies* the existence of God; an agnostic *does not know* if God exists. The agnostic

must be distinguished from the gnostic who asserts that our reason may transcend the limits of experience and therefore attain truths not capable of verification by either observation or experiment; he not only affirms the existence of God but claims to describe Him.

If in philosophy we could find a proposition in which all philosophers agree, we should without hesitation admit it to be true; if we could find one which has an obvious balance of authority, we should agree that its truth is probable. But so long as every philosopher contradicts the first principles of his predecessors, how can there be any certainty? It was Leslie Stephen who said that "the only agreement I can discover is that there is no philosopher of whom his opponents have not said that his opinions lead logically either to Pantheism or to Atheism." "When all the witnesses thus contradict each other, the *prima facie* result is pure scepticism. There is no certainty."

Leslie Stephen, one of the finest of Victorian scholars, was an agnostic. Thomas Henry Huxley was another, and from Huxley we may now usefully quote:

"Granted a fowl feels; that the chick just hatched feels, that the chick when it chirps within the egg may possibly feel; what is to be said of it on the fifth day, when the bird is there, but with all its tissues nascent? Still more, on the first day, when it is nothing but a flat cellular disc? I certainly cannot bring myself to believe that this disc feels. Yet if it does not, there must be some time in the three weeks, between the first day and the day of hatching, when, as a concomitant, or a consequence, of the attainment by the brain of the chick of a certain stage of structural evolution, consciousness makes its appearance. I have frequently expressed my incapacity to understand the nature of the relation between consciousness and a certain anatomical tissue, which is thus established by observation. But the fact remains that, so far as observation and experiment go, they teach us that the psychical phenomena are dependent on the physical."

Admittedly, Huxley's logic seems to be incontrovertible.

4. Theism.

The former Dean of St. Paul's (Dr. Inge) has told us that, as soon as he began to think seriously about the Foundations of Belief, it became clear to him that the centre of gravity in religion had shifted, in our day, from authority to experience. "To ascribe infallibility to the pronouncements of the institutional Church seems almost monstrous. Nothing can be more fantastic than the Tractarian theory that the General Councils were infallibly guided, but that the gift of infallibility went into abeyance when the Church was divided, like an old English peerage when there is more than one daughter but no son." "Fanatical loyalty to an ecclesiastical organization, which gives the Roman Church the driving force of a standing army, is the temper, not of Christ, but of the Jerusalem hierarchy who crucified him."

Nowadays few intelligent people venture to deny the existence of a God of *some* kind, perhaps Transcendental, perhaps Immanent. The late Professor E. W. Hobson happily drew the distinction this way: just as the arbitrary and sporadic acts of an absolute sovereign appeal to many minds as more striking, and more dramatic, evidences of power than are exhibited in the more even course of the orderly working of a constitutional government, the incalculable acts of a transcendental Deity, conceived as a despotic personality, appear to provide more cogent evidence of divine power than does the orderly and ubiquitous working of an immanent Deity. One's mind seems to long for a conception that can be easily pictured, and this is the real reason why a transcendental God finds more favour amongst ordinary people than does an immanent God. Any particular man's knowledge of the world is bound to be of a very composite character and to have been derived from many sources, and his particular conception of God is therefore bound to be, though perhaps quite unconsciously, influenced and coloured accordingly.

It has been justly said that "contentment with the regress to a God-creator or some similar notion is a mark of speculative indolence", for creation must necessarily be regarded as an event which took place at a definite date in the past, to which we can return by a temporal and causal regress. At one time this date was fixed as 4004 B.C. (see the Bible), and so it remained until geological and astronomical discoveries necessitated a vast extension of cosmic time, though a definite limit was still imposed on the extension. But why should theologians attach any importance to a temporal origin of the earth, seeing that we have been compelled to abandon the geocentric hypothesis and all its corollaries? The spectacle of the birth and death of worlds may actually be seen by the astronomer as he scans the heavens, and in that sense the earth and the solar system to which it belongs undoubtedly had a beginning and may be expected to have an end. These, however, are but local incidents in the cosmic process; what passes away here is being born, or is ripening to fruition, elsewhere. The more thoughtfully we consider the idea of creation as a special act or event that took place once upon a time the more highly improbable does it appear; it belongs to the same circle of ideas as the waving of a magician's wand. It was an old gibe of the Epicureans, familiar in Cicero's day, to ask how God employed himself before He created the heavens and the earth and why before doing so he had remained an idler for such a long time. Had He been just a solitary idler for untold ages, for infinite time, in fact, wrapped up in Himself, as Janet puts it, "entirely and in Himself an Absolute"! If so, how are we to picture this Absolute? as the universe considered in its mind-like aspect, as Haldane puts it? as a sort of soul animating otherwise inert matter? as just the universe considered comprehensively and all-embracing? What do we know, really *know*, about it? Nothing.

If we say that God is *infinite*, are we not using an incomprehensible epithet? To infer the infinite from the finite is, as Schiller conclusively argues, a fallacy like inferring the

unknowable from the known, and all arguments in favour of an infinite God must commit it. The attribute of infinity contradicts and neutralizes all the other attributes of God, and makes it impossible to ascribe to the Deity either personality or consciousness, or power, or intelligence, or wisdom, or goodness, or purpose, or object in creating the world; an infinite Deity does not effect a single one of the functions which the religious consciousness demands of its God. How, for instance, could an infinite God have personality, since assuredly this quality depends on limitation? Personality rests on the distinction of one person from another, and an all-embracing person is therefore an utterly unmeaning phrase. An infinite personality would equally embrace and impartially absorb the personalities of all finite individuals. And since an infinite God could have neither personality nor consciousness, neither intelligence nor wisdom could be ascribed to Him.

Julian Huxley is almost as uncompromising as was his famous grandfather in denying any ordinary personification of divinity, any conception of God which regards Him as a separate Being controlling the universe which He has created, any view which stresses God's transcendence rather than his immanence: and he readily agrees that theology now lays more and more stress on the immanent aspect of God, and on His super-personal aspects, which make of His nature something profoundly different from mere human personality. Indeed, the crude anthropomorphism of earlier days seems to have disappeared entirely. But who will dare even to outline the alternative picture, that of immanence? Nobody.

In the plane of scientific and historic inquiry, the territory of the unknown but possibly knowable stretches away indefinitely beyond that of the known, and between the two there lies a certain borderland of the uncertain and conjecturable. But the mystery which religious dogma formulates, purports to be a truth belonging to a plane above and beyond that which is subjected to man's scientific and historic inquiry,

a truth which cannot possibly be known clearly by him under his present limitations, a truth which defies exact expression and perfect intelligibility. Anything more than the dimmest shadows of real knowledge is not to be expected during man's slow rise from his savage origin. Another million years hence? Who shall say?

Meanwhile let us be content with the sublimest of all generalizations, "God is love". As the late Canon Dearmer put it: "Reason demands an all-embracing Personality: love provides it. Reason demands an ultimate unity: love attains it."—Satisfactory? No. But it is all that we can see at present through the impenetrable mists that surround us.

5. Jesus, the Christ.

It may be frankly admitted that those to whom the power of the spirit of Christ is a living reality are exceedingly apt to interpret in a non-natural way Christ's human life. But unless Jesus was a man with limited knowledge, with human attributes, passions, and temptations, His life can be to us no true model, but, as Professor Gardner put it, only a mirage. Some of the most touching episodes in the life of Jesus—such as the Temptation, the scene in the Garden of Gethsemane, even the death on the cross—lose all force and meaning if we deny the true and natural humanity of the sufferer.

The assertion of the miraculous origin of the birth of Jesus is based mainly on a verse of *Matthew* (i. 20), in which it is stated that an angel appeared unto Joseph *in a dream*. Some early variant readings in Matthew and Luke seem to belong to a time in which the virgin-birth was not generally acknowledged. For instance the early Syrian version of the *Codex Sinaiticus* reads (*Matthew* i, 16) "Joseph to whom was betrothed Mary the Virgin, begat Jesus." The sonship to David is asserted in various places in the Gospels and Epistles; and it implies descent from Joseph, since it was maintained by early Christianity that Joseph was a descendant of David, while the descent of Mary was not known or not regarded.

Paul seems not even to have heard of the story of the miraculous birth.

It is of course true that the story of the virgin birth is still not only accepted but is wrapped up in religious awe by many devout Christians, and could not be ejected from their minds without causing the downfall of the whole structure of their religious belief. But those who are expected in future to accept as a fact of objective history the virgin birth of Christ must, as Professor Gardner observes, be trained not in the breezy air of the universities but in the sheltered cloisters of theological academies.

6. The Creeds.

Any man who seeks admission as an ordained clergyman to the Church of England has to subscribe to the thirty-nine Articles in the Book of Common Prayer, and therefore by the eighth article he recognizes, as Matthew Arnold explicitly pointed out, the three Creeds to be *science*, "thoroughly to be received and believed". But, as Arnold emphatically added, whatever else the three Creeds may be, they are certainly *not science*, truly formulating the Christian religion. And no one who feels convinced that they are not, can sincerely say that he gives a general consent to whatever is contained in the Prayer Book. Can any educated man honestly subscribe to the last sentence of the article, viz. the Creeds "may be proved by most certain warrants of Holy Scripture"? Does any professing Christian still believe that "everlasting fire" is the fate of all "who have done evil"? It is monstrous that such a statement should still be retained in the Prayer Book.

The writer of the Athanasian creed consigned to perdition all who did not agree with his theology, and this remained a commonplace of Christian doctrine down to the middle of the nineteenth century. Then the outrageous idea began to offend the conscience of many thinkers who, as Professor Kirsopp Lake gently puts it, "feeling quite unable really to understand the delicate metaphysics of the doctrine of the Trinity, especially when stated in an elabo-

rate series of paradoxically antithetical statements, doubted whether failure to believe what they could not understand would necessarily consign them to the flames of hell." In some measure the conscience of the laity was quieted by the suggestion of mistranslation, but the doubt rapidly spread, and not a few clergy began to drop the creed altogether. From time to time suggestions have been made to amend all three creeds: they are so obviously full of doubts, and contain not a few palpable absurdities. But there are degrees of credibility, as well as of incredibility, and formally nothing has been done. When Dr. Henson was appointed Bishop of Hereford, Bishop Gore protested on the ground that Dr. Henson's published writings indicated disbelief in some articles of the creed. The controversy came to an end, however, when Dr. Henson stated that he accepted the creed *ex animo*. Was an adversary ever more cleverly foiled? *Ex animo*: what does it mean? Bishop Gore, a recognized classical scholar, deemed it wise to keep out of the trap, and the controversy closed.

A distinguished contributor to *Foundations* pointed out that normally all educated persons ought to emancipate themselves from tutelage *pari passu* with advancing knowledge and experience, inasmuch as growth ought to be harmonious upon all sides of a man's nature, and the attempt to combine intellectual maturity in all other relations of life with a theology stereotyped in childhood is only too apt to lead to shipwreck to one's faith. To criticize becomes in such circumstances at once a right and a duty: a stage is reached in the inner life of the spirit at which the individual claims, and is bound in the name of intellectual honesty to claim, the right to question, and, if need be, to deny, the validity of inherited and traditional dogma.

It is nearly a century since Jowett, afterwards Master of Balliol, wrote his famous contribution "On the Interpretation of Scripture" to *Essays and Reviews*. In the course of his Essay he said: "In natural science it is felt to be useless to build on assumptions; in history we look with suspicion on

a priori ideas of what ought to have been; in mathematics, when a step is wrong, we pull the house down until we reach the point at which the error is discovered. But in theology it is otherwise; there the tendency has been to conceal the unsoundness of the foundation under the fairness and loftiness of the superstructure. It has been thought safer to allow arguments to stand which, although fallacious, have been on the right side, than to point out their defect. And thus many principles have imperceptibly grown up which have overridden facts. . . . The accuracy of the Old Testament is measured not by the standard of primæval history, but of a modern critical one, which, contrary to all probability, is supposed to be attained; this arbitrary standard once assumed, it becomes a point of honour or of faith, to defend every name, date, place, which occurs."

And it was another distinguished Balliol man (N. S. Talbot, afterwards Bishop of Winchester) who reminded us how pointedly the world is now asking questions. Christianity and its traditional theology have come down to us from an age very different from our own, an age when the sun and the stars moved round the earth, when the meaning of natural law and evolution was only dimly apprehended, when the psychology of religion and the critical study of ancient documents were yet unborn. Talbot pointed out that the world was making an insistent call for religion, but that it would refuse to accept a religion if its theology was out of harmony with science, philosophy, and scholarship. "Religion, if it is to dominate life, must satisfy both the head and the heart, a thing which neither obscurantism nor rationalism can do." Parts of the old creeds are in tatters. Why does the Christian Church, Catholic and Protestant alike, shirk the fundamentally important task of credal reconstruction?

7. Creeds and Conscience.

When the Christian creed really ruled men's consciences no word was ever uttered against the doctrine of hell. We

need not go back to Victorian times to find examples of ignorant young curates who gravely told their congregations that they would be burnt everlastingly if they did not share his superstitions. In a conversation during which some disrespectful remarks were made about hell, a loyal clerical friend of that establishment said triumphantly: "But absurd as it may seem, you cannot disprove it!" It is fairly safe to assume that that man's school terminal records in mathematics and classics were kept safely under lock and key.

People have never felt greatly disturbed if a man maintained disbelief in a demonstrable fact; they merely smiled. But if he denied age-long and popular doctrines tenaciously held by the multitude who are admittedly quite unfamiliar with the art of testing intellectual foundations—such doctrines, for instance, as that of the existence of a personal God or that of the immortality of the soul—then that man ran the serious risk of incurring public disapprobation, even opprobrium, though whether the opprobrium would be intellectual or moral could rarely be stated with certainty. Logic consistently refused to enter into the argument, and remained smilingly aloof.

The compromise which most people feel to be necessary in politics has a strong tendency to react in the realm of the intellect, with the consequence that the love of strictly accurate reasoning and even of truth itself tends to take a subordinate place. This weakness has been adopted by theology for her own use, and in her sphere truth is compelled to occupy a position subordinate to emotional comfort.

The greater part of men's knowledge and beliefs is taken without verification from their parents, teachers, friends, acquaintances, books, and newspapers.

A subtle Italian thinker of Renaissance times taught that religion is necessary to effective government, and that it may be the duty of a ruler to support a religion which he believes to be false. The view that a false religion is indispensable as a social machine was general among ancient believers, and even to-day it is common in one form or another. Religions

are constantly defended on the ground not of truth but of utility. All down the ages intelligent men have been well aware that a subservient spirit in the masses of the people can be brought about only by the cultivation of some form of religious faith, a method diametrically opposed to the cultivation of the reason.

Down to the end of the last century, and even later, not only were dangerous political opinions regarded as the inevitable sequel of religious unbelief, but religious unbelief was also regarded as the inevitable sequel of dangerous political opinions. The two things were believed to form a vicious circle. The subtleties of a well thought-out theology were therefore considered to be an invaluable instrument for making the working classes subservient. Keep these classes superstitious and it is very easy to keep them contented.—That age is past, though some of its ghosts still walk.

8. The New Religious Outlook.

As I knew well from personal experience, the famous T. H. Huxley was a ruthless and pugnacious logician: his grandson Julian is perhaps almost equally ruthless, but when he takes the ring he wears well-padded gloves as well as a disarming smile. His blows are as hard as his grandfather's, but somehow he is far more persuasive. Here is a sentence from his *Scientific Humanism*: "the transference of the sense of supreme sacredness from fear to love, accomplished by Jesus, led man to wholly new levels of religious value." And his persuasiveness is almost always deeply tinged with irresistible logic. In *The Conflict between Science and Human Nature*, for instance, he says: "Advancing science has had an equally contradictory effect upon the religious outlook. By showing the baselessness of traditional theologies, it seemed at one time to be giving religion itself a mortal blow. But when we come to look deeper, we find the inescapable fact of religious experience, which no scientific analysis can remove. Thus, by forcing religious thought to distinguish between theological scaffolding and religious core, science

has actually encouraged the growth of a truer and more purely religious spirit. To put it another way, if science has robbed religion of many of its certitudes, those certitudes were in a sphere improper to religion. True religious certitude is not in the realm of intellect at all, but concerns values and a special attitude towards them. Science has evicted religion from the universal but uneasy throne she occupied in the Middle Ages, but she has helped her to ascend her true and permanent throne of spiritual experience."

What bitter and unreasoning partisans are the more extreme members of some of the Christian churches, how unreasonable is their hate, how ingrained is their belief that they alone are blessed by God and that therefore their persecution and bigotry are fully justified. And they claim to be Christians! to be faithful followers of Christ!

What infinite harm the old fairy-tales of the Bible have done!—walking on the water, the multiplying of loaves, the resuscitating of corpses, a heavenly judge appearing with trumpet in the clouds while we are yet alive: the absurdity of it all: How utterly insignificant is the value of such notions when we try to evaluate Christianity—real *Christianity*.

As the present Archbishop of York so wisely points out in his *Christianity in Thought and Practice*, Philosophy and Religion each needs the other. Philosophy needs religion in order to draw a quickening impulse from its realms; religion needs philosophy in order to keep itself purged from its perpetual tendency to superstition.

9. Immortality.

There is universal acknowledgment that intelligent people differ fundamentally as regards data of perception and conception, and full recognition of the fact is fundamental in any investigation of the deeper aspects of thought. Inferences are therefore bound to be in conflict, with the consequence that the question of their validity is naturally bound to arise. Obviously, then, even in this age of keen intellectual

activity some inferences will necessarily be erroneous. Is it not thoroughly irrational to assume that thought has reached the stage when inferences are final and never again to be questioned? That our particular interpretation of the universe is not accepted by others is certainly not a proof that the others are less rational than we are. From a scientific point of view, the prevalence or persistence of beliefs which we reject, repudiate, or are unable to understand is of the highest importance for our evaluation of human nature. It is quite unscientific to regard such phenomena as based upon illusions, as irrational, or as survivals from some past age. How can we doubt that the study of religions is still in its early infancy?

We are told with a good deal of emphasis and with much implied certainty by Professor Cyril Joad that "for thousands of millions of years the universe, so far as we know, was lifeless. Then slowly and hesitatingly living organisms appear. In the vast immensities of astronomic space and geologic time, their life seems a tiny glow flickering uncertainly, and, as far as the teaching of science goes, destined in the end to be frozen out of the one corner of the world in which it has appeared." There is some little doubt about the meaning Professor Joad wishes us to assign to the terms "universe" and "world". Presumably the "universe" is the containing whole, and the world that tiny speck of it with which we are familiar. What then does he *mean*? He goes on: "but if life is recent in time and insignificant in space, human life is incomparably more recent and more insignificant. For twelve hundred million years there has been life, for only a million human life. During only a very small part of these million years have human beings been able to think; and the minds, by which their thinking is conducted, are lately developed products, makeshift and imperfect, bearing upon them unmistakable marks of the transitional. As they have been evolved from an animal consciousness which was below the level of the human mind, so in all probability will they be succeeded by a form of intelligence which is as unlike

our minds and as superior to them as our minds are unlike and superior to the consciousness of protozoa." These statements are far too strongly flavoured with the dogmatic certainty of forty years ago. Do they connote proved facts, or are they mere hypotheses?

Professor G. T. Ladd, that distinguished man of Harvard, strikes a much more cautious note. He points out that the modern discoveries bearing on the mystery of the constitution of matter, whether we think of matter in its minutest forms or as vast and innumerable world-systems, have not yet led to knowledge but only to provisional *hypotheses*. And when we come to the science of living organisms, whether it be the life of the individual or of the species, or whether it be the evolution of one form of life from another, again our knowledge is most emphatically not final, it is only hypothetical. Biologists do not quite despair of ultimate victory, but the ablest of them admit that at present they are absolutely baffled. The very best attempts at disclosing the secret of human personality cannot at present be regarded as anything more than *hypotheses*. To the intellect the secret cannot be a truth demonstrable by scientific method, but to religious faith it can be an unshakable hope.

And the future? the far-off future? and ourselves?

One of the most thoughtful and distinguished of our bishops bids us to think of all the human effort that has gone to the building of civilization. "All that is finest in humanity has been given for centuries—and will probably be given for ten million years or for longer—to build on earth what Christians dream of as 'the city of God'. Yet some day—surely, certainly, unalterably—the sun's light and heat will pass away; and the earth will become as lifeless as the moon. Man will vanish. If there be no life beyond the grave, then of all man's achievements nothing will remain save, possibly, a few lifeless ruins on a dead earth. Is this reasonable? Can God have thus made man for nought? I cannot believe it.

"Thus because I believe that the universe and all that is within it were fashioned by God, I think that man's per-

sonality survives the death of his body." And the Bishop adds: "I find myself holding fast to the belief that God preserves what is worth keeping. He has not made man for a whim to throw him in the end like a discarded toy on to some dust-heap of forgotten things. There is, in man's spirit, that which is worth keeping—and it shall never die."

At this early stage of man's development, logical and final proof of his immortality is denied him. Nevertheless the belief is overwhelming and irresistible.

But what does the term immortality really signify? Alas! we do not know.

10. Voices from London and Washington.

In these stressful and unhappy war-days, it is pleasant and instructive, and it is often comforting, to turn to the daily fourth leader of *The Times*. We may quote from the one which appeared on 22nd October, 1940:

"The natural man is an extrovert, wholly occupied with the beauty, the activities, and the delights of a world that is on the whole very kind to him. When that dear, familiar world is shattered to bits about him, he must reverse his stance, plumb the depths of his own being, and seek to gain the kingdom of his own soul. He will fail in that quest, too, if his novel introspection is confined to brooding upon his own troubles and feeling pity and anger on his own behalf. His one hope is to make afresh the grand discovery that the well-being of that inner life depends upon the degree to which it can be emptied of the very thought of self. He must re-externalize himself, but in a fresh direction. No longer the happy hunter of the things that please and satisfy himself, he must pursue the things that help and comfort those about him. It is not a bad plan, when he is particularly tempted to feel sorry for himself, to set about comparing his own lot with that of others. In considering their misfortunes, and counting his own mercies by comparison, his frame of mind will become the spiritual antithesis of that delight in frightfulness which makes the enemies of to-day so peculiarly repulsive. It will lead him speedily from thought to action, generating the desire to help his fellows, by sympathy and kindness in the daily routine of work

and travel, by putting the well-being of others first in times of alarm and danger, by giving as generously as means permit towards the succour of the homeless and the despoiled. Such a negation of self will leave no blank within, but a fullness of peace which can be won in no other way."

Finally we may quote from the Third Inaugural address of the President of the United States, Mr. Franklin D. Roosevelt, delivered at Washington, 20th January, 1941. In it he declared that, in the face of great perils it was the strong purpose of America "to protect and perpetuate the integrity of democracy". Democracy, he said, was in the end the most unconquerable of all forms of society.

"No, democracy is not dying! We know it because we have seen it revive and grow. We know it cannot die because it is built on the unhampered initiative of individual men and women joined together in a common enterprise—an enterprise undertaken and carried through by the free expression of a free majority. We know it because democracy, alone of all forms of government, enlists the full support of men's enlightened will. We know it because democracy alone has constructed an unlimited civilization capable of infinite progress in the improvement of human life. We know it because, if we look below the surface, we sense it still spreading on every continent; for it is the most humane, the most advanced, and, in the end, the most unconquerable of all forms of human society."

CHAPTER IX

The Condemnation of Science : the Verdict

What is the Verdict? Is Science guilty or not guilty of the charges brought against it?

The evidence for and against seems to be about equally balanced, and it is unlikely that any English jury would agree. A Scottish jury would probably bring in the verdict, *Not Proven*. But would not almost any jury append to their verdict the rider that science seems to be rather indifferent to the results of its work on the happiness of humanity? and perhaps the further rider that not a few of the men who devote their lives to unearthing the secrets of nature really think less of the welfare of mankind than of their own en-registration on the roll of personal fame?

If science, philosophy and theology took their seats at a round table, and sought out and stressed harmonies rather than discords, might not their work contribute, in a much greater degree, to the permanent happiness of mankind?

WORKS OF REFERENCE

The following is a list of the books from which the writer has quoted or which he has consulted. Most of the authors named will be recognized as authorities of eminence. A few of them have now passed away, but the majority are happily still with us. All the books are worth reading and pondering over.

1. *An Agnostic's Apology*, Leslie Stephen.
2. *An Orientation in Science*, C. W. Watkeys, and others.
3. *Cambridge Essays on Education*:
 - (i) *Introduction*, Viscount Bryce.
 - (ii) *The Training of the Reason*, Very Rev. W. R. Inge.
 - (iii) *The Place of Science in Education*, W. Bateson, F.R.S.
4. *Christianity in Thought and Practice*, Archbishop Temple.
5. *Culture and Anarchy*, Matthew Arnold.
6. *Dangerous Thoughts*, Lancelot Hogben.
7. *Deeper Causes of the War and its Issues*:
 - (i) *Rights and Values*, Professor W. G. S. Adams.
 - (ii) *Herd Instincts*, Professor Gilbert Murray.
 - (iii) *Sowing and Reaping*, Rt. Hon. Viscount Samuel.
 - (iv) *The War and the Crisis for the Spirit of Man*, The Very Rev. Dean Matthews.
 - (v) *The Crisis of Civilization*, Sir R. Livingstone.
 - (vi) *Science and Human Values*, Sir R. Gregory.
 - (vii) *The Problem of an Order of Europe*, Prof. Ernest Barker.
 - (viii) *Peace by Federation?*, Sir W. Beveridge.
8. *Domain of Natural Science*, Professor E. W. Hobson.
9. *Endless Quest, 3000 Years of Science*, F. W. Westaway.
10. *Foundations*, The Bishop of Winchester and others.
11. *Foundations of Belief*, Arthur J. Balfour (later, Earl Balfour).
12. *Frustration of Science*, Prof. P. M. S. Blackett, and others.

13. *Is there an After Life?* (in *The Mysteries of Life and Death*), Rt. Rev. E. W. Barnes.
14. *Lay Sermons*, Edward Caird, former Master of Balliol.
15. *Liberal Education*, T. H. Huxley.
16. *Modern Science*, Professor Herman Levy.
17. *Next Hundred Years*, C. C. Furnas.
18. *Outspoken Essays*, Very Rev. Dean Inge.
19. *Philosophical Aspects of Modern Science*, Professor C. E. M Joad.
20. *Possible Worlds*, Professor J. B. S. Haldane.
21. *Riddles of the Sphinx*, F. C. S. Schiller.
22. *Power*, Bertrand Russell.
23. *Science and Christian Tradition*, T. H. Huxley.
24. *Science and Civilization*, B. Lovell.
25. *Science and Human Experience*, Professor Herbert Dingle.
26. *Science for the Citizen*, Lancelot Hogben.
27. *Science, Religion and Reality*, Introduction by Lord Balfour (ed. J. Needham).
28. *Science To-day and To-morrow*, W. Kaempffert.
29. *Scientific Method*, F. W. Westaway.
30. *The Social Function of Science*, Professor J. D. Bernal.
31. *The Study of Religions*, Stanley A. Cook.
32. *Vale*, Very Rev. Dean Inge.
33. *What Science Stands for*, Professor A. V. Hill, and others.
34. *What dare I think?*, Julian Huxley.

INDEX

- Abstract science, 19.
- Adams, Prof. W. G. S., 54.
- Agnosticism, 112.
- Agriculture, 25.
- Alexander the Great, 52.
- Ancient Egyptians, 36.
- Animals and Plants, 24.
- Animals as automata, 33.
- Anthropology, 27.
- Aristarchus, 37.
- Arnold, Matthew, 93, 105.
- Astronomy, 27.
- Atomic theory, 47.
- Aviation, 21.
- Avogadro, 47.
- Axioms, 18.

- Balfour, 4, 109, 110.
- Barker, Prof. E., 59.
- Beadnell, Admiral, 17.
- Belief and Conviction, 8.
- Bernal, Professor, 72.
- Beveridge, Sir W., 60.
- Biochemistry, 25.
- Biology, 24.
- Boarding and Day Schools, 99.
- Botany, 24.
- British reasoning, 97.
- Bryce, Viscount, 88.

- Caird, Master of Balliol, 93.
- Carr, Prof. E. H., 102.
- Carrel, Professor, 29.
- Causes of war, 54.
- Chemistry, 23.
- Chinese civilization, 62.
- Christian religion, 15.
- Christianity, 110.

- Churchill, W. S., 101.
- Civilization, 62.
- Civilization and Culture, 64.
- Coercion of reason, 6.
- Conviction and Prejudice, 1.
- Creeds, 118, 120.
- Cruelty in war, 10.
- Culture and Anarchy, 94.
- Curies, the, 22.

- Dalton, 40, 47.
- Darwin, 24, 41.
- Dearmer, Canon, 117.
- Democracy, 70.
- Dingle, Professor, 112.
- Discipline and Liberty, 67.

- Edison, 21.
- Education, French and English 100.
- Education, present tendencies, 98.
- Einstein, 48.
- Electricity, 22.
- Emotion and Reason, 78.
- Epicureans, 115.
- Evolution, 25, 26.
- Ewing, Sir Alfred, 12.

- Faraday, 40, 73, 88.
- Fields of experience, 108.
- Flinders Petrie, 64.
- French science, 74.

- Galileo, 14, 38, 39, 53.
- Gardner, Prof. Percy, 117.
- Gay-Lussac, 47.
- Genetics, 25.
- Geology, 26.

- German distortion of facts, 13.
 German science, 73.
 Goddard, Professor, 29.
 Goebbels, 69.
 Gore, Bishop, 119.
 Gramophone records, 31.
 Gregory, Sir Richard, 27, 59, 79.
 Grey, Lord, 81.

 Haldane, Professor, 76, 115.
 Heat and Mechanics, 21.
 Henson, Bishop, 119.
 Heredity, 25.
 Hindu civilization, 62.
 Hinsley, Cardinal, 111.
 Hipparchus, 37.
 Hitler, 8, 14, 69.
 Hobson, Prof. E. W., 114.
 Hogben, Prof. Lancelot, 76, 96.
 Human body as a machine, 30.
 Huxley, Julian, 116, 122.
 Huxley, T. H., 24, 84, 113, 122.
 Hypotheses in science, 46.

 Ideas, 6.
 Immanence, 116.
 Immortality, 123.
 Infinite God, 115.
 Inge, Dean, 87, 91, 114.
 Intellectual assent, 7.

 Janet, 115.
 Jesus Christ, 117.
 Joad, Prof. Cyril, 124.
 Joule, 53.
 Jowett, Master of Balliol, 119.

 Kepler, 38, 39.

 Ladd, Professor, 125.
 Lake, Prof. Kirsopp, 118.
 Lamb's Chinaman, 35.
 Law of Gravitation, 48.
 Leonardo, 53.
 Levy, Professor, 95.
 Light, 22.
 Livingstone, Sir Richard, 58, 91.
 Lockyer, Sir Norman, 27.
 Lyster, Dr., 72.

 Marconi, 22.
 Mass mind, 66.
 Mathematics, 18.
 Mathematics and Science, 17.
 Matthews, Dean, 57.
 Maxwell, Clerk, 73.
Mein Kampf, 14.
 Miracles and Science, 112.
 Modern liners, 30.
 Mosaic commandments, 51.
 Murray, Prof. Gilbert, 55, 69.
 Mussolini, Bruno, 11.

 Nazi youth, 92.
 Nazis and Fascists, 69.
 Newton, 39, 48, 73.
 Novelty and Obsolescence, 65.

 Old Testament, 51.
 Opinion and Prejudice, 6.

 Percy, Lord Eustace, 80.
 Physics and Chemistry, 20.
 Physiology, 24.
 Planetary paths, 38.
 Political terms, 68.
 Power, 67.
 Power of ideas, 6.
 Pre-adolescent convictions, 1.
 Prejudices and Opinions, 6.
 Preparatory School boys, 3.
 Primitive man, 34, 63.
 Progress and Decadence, 65.
 Progress and Decay, 65.
 Ptolemy, 37.
 Public Schools, 100, 106.

 Quantum hypothesis, 48.

 Relativity, 48.
 Research workers, 43.
 Röntgen, 22.
 Roosevelt, President, 127.
 Russell, Bertrand, 11, 65.

 Samuel, Viscount, 56.
 School influence, 1.
 Science and Civilization, 62.
 — — Education, 84.

- Science and religion, 108.
 — — the future, 28.
 — characteristics in different countries, 73.
 — condemnation and verdict, 128.
 — friend or enemy of civilization? 76.
 — in the Dock, 10.
 — in the nineties, 16.
 — its methods, 33.
 — its vast range, 95.
 — main source of power? 71.
 — public ignorance of, 104.
 — research, 25.
 — the field it covers, 18.
 — tripos, 16.
 Scientific laws, 45.
 — theory, 45.
 — workers, 36, 42.
 Scientists, British, 73.
 Smuts, General, 87.
 Socialism and Individualism, 93.
 Soviet science, 74.
 Spencer, Herbert, 90.
 Stamp, Sir Josiah, 77.
 Stephen, Leslie, 113.
 Svedberg, 21.
 Talbot, Bishop, 120.
 Telescope, Californian, 28.
 Temple, Archbishop of Canterbury, 85.
 — — — York, 123.
 Theism, 114.
 Theories of Science, 46.
 Thompson, Sir D'Arcy W., 82.
Times, The, 126.
 Toleration and Dogmatism, 86.
 Totalitarianism, 69.
 Transcendentalism, 114.
 University Life, 1.
 Virgin Birth, 117.
 War in History, 51.
 — weapons, 52.
 Whewell, William, 90.
 Whitehead, Prof. A. N., 88.
 William the Conqueror, 52.
 World language, 80.
 — reconstruction, 79.
 Zimmern, Sir Alfred, 79, 103.
 Zoology, 24.

11862

